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PRINCIPLES OF HYGROMETRY

Important Facts Pertaining to the Removal or Production of Water Vapor in the Atmosphere

BY JOS. H. HART, PH.D.

The effect of moisture in the air in a large number of industries is very pronounced and is in nearly every case deterrent to the best efficiency of operation, but until recently no practical attempts to remove it on a large scale have been made, and the subject of hygrometry has appeared in a theoretical rather than a practical aspect to the majority of engineers. However, the wonderful adaptation of mechanical refrigeration in the removal of moisture from the blast in iron furnace operation, and its consideration in the operation of cooling towers, and also the possible application of mechanical refrigeration to the drying of blasts of any kind and wherever used, have brought the subject of moisture in the atmosphere and the laws which govern it to the notice of the practical engineer. While the subject of hygrometry is easily understood, there exist to-day comparatively few efficient methods of measuring it, and the majority of the devices with this object in view utilize various systems of measurement, which render the obtaining of accurate knowledge readily in this field a comparatively difficult process. In fact, very little of any real value is known by the average engineer.

The province of hygrometry is to determine the quantity of aqueous vapor contained in a given volume of air. This quantity is very variable. The atmosphere is seldom, if ever, completely saturated with vapor, even in our climate, nor is it ever completely dry. The presence of moisture can be readily detected if hygroscopic substances, such as chloride of calcium or sulphuric acid, be exposed for any time to the air, as they absorb considerable water vapor. As the air is in general never saturated, the ratio of the quantity of aqueous vapor actually present in the air to that which it could contain if it were saturated, the temperature being the same, is called the hygrometric state or degree of saturation.

The absolute moisture in the air is measured by the weight of water actually present in the form of vapor in the unit of volume. There is this remarkable fact about vapors in general. Two vapors or a vapor and a gas will occupy the same space just as if the other were not present. Thus water vapor is present everywhere in the space surrounding the earth, and the quantity of this vapor depends simply upon the temperature of the vapor and its contiguity to a source of the liquid. If immediately in contact, it in general becomes saturated for that temperature in precisely the manner that steam becomes saturated in a boiler, and remains so. A saturated vapor in this department has the same significance as a saturated vapor in steam or ammonia work. It means that if the pressure is increased or the temperature lowered condensation occurs, or, in other words, that the space contains all of the vapor possible at that pressure and temperature. Thus the space surrounding the earth contains water vapor independent of the quantity of air present and a function only of the temperature and degree of saturation.

The absolute moisture in the air varies with the temperature in the course both of the year and of the day. If summer there is a maximum in the morning and evening and a minimum at 3 A.M. and 3 P.M., because of the ascending current of air which carries the moisture upwards. The absolute moisture is greatest in the tropics, where it represents a pressure of 1 inch of mercury, while in our latitude it does not exceed 2/5ths of an inch. The relative moisture, however, is on the average greater in high than low latitudes. It is at its minimum in the hottest and at its maximum in the coolest part of the day. It varies in different regions. It is greater at a distance from a large body of water than when near at hand. Thus in England the relative moisture is about 80, in Italy about 60, and in Siberia about 40 per cent. When the air is cooled the relative moisture increases until it ultimately becomes saturated. This accounts for the production of rain and dew and snow. They are invariably due to the cooling of atmospheric conditions below the saturation point of the aqueous vapor present.

Our judgment in regard to relative humidity varies greatly. Thus in summer we say that air is very dry because it contains an average of 1/40th of a pound of water to the cubic yard, whereas it could contain twice this amount without condensation. On the other hand, in winter, if the same volume contains 1/80th of a pound, we say it is very moist, because it is very near the saturation point and a very slight diminution in temperature produces a deposit. When a room is warmed the

quantity of moisture is not diminished, but the humidity of the air is lessened, because its saturation value is raised. The air may thus become so dry as to be injurious to the health, and hence rises the precaution of placing vessels of water in such a room.

Boyle's law applies to non-saturated vapors as well as to gases, and the presence of another gas or vapor has no effect on the operation of this law. Hence, it follows that with the same temperature and volume the weight of vapor in an unsaturated space increases with the pressure and, therefore, with the pressure of the vapor itself. Instead, therefore, of using the definition of hygrometric state as the ratio of the quantity of vapor present to the quantity of vapor present in a saturated state it can be defined as the ratio of the pressure of the vapor which the air actually contains and the pressure of the vapor which it would contain at the same temperature if it were saturated. Thus if f is the actual pressure of aqueous vapor in the air, and F that of the saturated vapor at the same temperature and N the hygrometric state, we have that N is equal to $f \div F$, whence f equals $F \times N$. As a consequence of this second definition it is important to notice that the temperature having varied, the air may contain the same quantity of vapor and yet not have the same hygrometric state, for when the temperature rises the pressure of the vapor which the air would contain if saturated increases more rapidly than the vapor actually present in the atmosphere; and hence the relation between the two forces, or the hygrometric state, becomes smaller.

This relation N is what is generally measured in the majority of hygrometers. Given this value and the pressure and temperature obtainable from other sources, the absolute moisture in the air, or the quantity of water present, can be calculated by suitable formulæ. The absolute quantity of water present in the air can also be obtained directly by what is known as a chemical hygrometer. This consists of some hygroscopic substance which is weighed and then made to absorb all the moisture in a certain quantity of air. It is then reweighed and the quantity of moisture obtained by subtracting the two weights. This gives absolute values, and is the only thing of much importance in refrigeration work in the removal of moisture from the air. The only necessary factors to consider in a problem of this kind are, the quantity of air which must be furnished, the quantity of moisture that it contains, and the temperature to which both must be cooled in order to condense moisture. It is obviously impossible to cool the air to a sufficient extent to remove all the moisture if no limitations of pressure are considered, but in practice, with suitable pressures and temperatures, it is possible to condense almost the entire amount. The amount condensed for a given temperature depends primarily upon the pressure, and thus in different applications of blast operation different cooling temperatures must be maintained. The removal of the moisture from the air blast in iron furnace operation increases the production of the iron on account of the saving in heat and its concentration in the furnace. Water vapor has a high specific heat and when injected into the furnace absorbs a large quantity of heat in its passage. Further, a process analogous to that in the production of water gas goes on and the water vapor present at this high temperature is decomposed, with the subsequent loss in the furnace of its heat of decomposition. This decomposed material unites with carbon partially and goes on into the exhaust, where it gives up its heat by recombination and further increases the heat waste in the exhaust. It is analogous in this respect to the nitrogen present in the air, but is 10-fold as destructive in its effect. The cooling of the air is lost in the furnace, since the air must be reheated, and further, the degree of cooling affects the efficiency of the refrigerating device; hence all of these factors must be considered in determining the degree to which air must be cooled, and no fixed values can be given. Sufficient data are not at hand and results can only be obtained from practice.

Of course, it goes without saying that air can be cooled more efficiently from a practical point of view when under pressure and the process of removal of the moisture continued more efficiently; but the behavior of the water vapor during compression of the air is an important factor and also enters to disturb results for best efficiency. The best method of considering the behavior of water vapor in air and its effect on efficiency is to regard it separately in all its changes. Thus when air is compressed and has water vapor in it we can get the best conception of the results by regarding each material as separated and the process performed in this state followed by a recombination. Thus water vapor, if separated and compressed, will condense partially, if not heated at the same time, and a consideration of the phenomena that occur under these conditions shows results exactly similar to those holding in steam work. In general, with increase in pressure on a condensable vapor at its saturation point there results a considerable condensation which gives out its heat of liquefaction. If air is compressed the work done on it heats it somewhat and the presence of water vapor, also compressed, heats it still more on account of the condensation of the water. The mixture of water vapor and air may be heated to such an extent as almost to evaporate the water again, but the general result is to increase the working pressure of compression, thus diminishing the efficiency of the plant.

In general, it can be said again, the whole phenomenon of moisture in air, and its application, can be best considered by regarding the moisture as occupying the space independently of the air present. Thus in cooling and drying devices of all kinds, advantage is taken of the fact that an unsaturated vapor tends to become saturated when immediately in contact with a liquid of its own substance, and tends to remain so. Thus, in cooling-tower work we can neglect the presence of the air and regard the space surrounding the cooling tower as filled with water vapor, in a more or less saturated condition. The presence of the air is an advantage from a mechanical point of view, simply by furnishing a convenient carrier for the water vapor, or by offering something by which the water vapor can be conveniently held and moved. Thus the efficiency of a cooling tower depends absolutely on the quantity of saturated vapor which can be brought into immediate contact with the water, and this depends, within certain limitations, upon the quantity of air which can be brought under the same conditions and upon the surface of the water to be cooled. A great mistake is often made in cooling-tower practice by using fans to drive the air rapidly through the entire length of the tower. The air is merely a conveyor of the unsaturated water vapor. This becomes saturated almost immediately upon contact with the first layer of water in the tower, and the further progress of this saturated vapor, and the air which drives it, is a distinct economic loss in the operation of the plant. To-day it is

generally recognized that atmospheric cooling towers are much superior, from an efficiency point of view, to those operated by fans. A mistake is often made in this practice by considering the temperature of the substances involved. Unsaturated water vapor which has been heated requires a greater additional quantity of water to make it saturated. Hence it is much better to use warm air in a cooling tower than cold, anomalous as this statement may appear. The cold air does cool off the hot water to a certain extent by a conduction and contact with its surface, but air is notoriously a poor conductor, and hence the advantage derived from this factor is very small. Hot air means that the water vapor is hot also and less saturated than before, if such a term can be used, and the relative humidity, N, as has been used in the preceding formulæ, is much less. This is a point which should not be lost sight of in cooling-tower work, or drying work of any kind, and modern practice seems to bear out this statement. As a further application the utilization of superheated steam as a drying device is a distinct example of this development. Superheated steam, although very hot when allowed to go over moist materials, rapidly absorbs the water from them and actually cools them below their former temperature, although the amount is nowhere near as great as in cooling-tower practice, since the water vapor in contact is a fairly good conductor of heat.

Now, in regard to the development of modern applications in this field. Results can only be obtained by determination of the actual quantity of water vapor present per unit of volume. Various instruments, in addition to the chemical hygrometer, have been developed for measuring N. The devices are purely empirical in their methods and in the results attained. Thus the wet bulb hygrometer consists simply of two thermometers, one of which registers the temperature of the air and the other one registers a different temperature which is attained by the following process. The bulb of the thermometer is surrounded by lamp-wick, which is connected to a small vessel containing water. The wick draws up moisture from the water and evaporation occurs from its surface into the air. The rapidity of evaporation depends upon the relative dryness of the air, or upon N. The water in its evaporation absorbs its own heat of liquefaction from surrounding bodies and produces a distinct cooling effect on the bulb of the thermometer, similar to that of the refrigerating machine. From the difference in temperature of the two thermometers, curves have been drawn and marked empirically with the degree of humidity of the air, and hence N can be determined by this method. There are a large number of hygrometers of this general type, but they are more or less inefficient in operation and subject to considerable error. Thus, if the above hygrometer comes in a current of air the evaporation produced is much greater, the temperature fall is much greater, and the resulting reading of N by the instrument undergoes a serious error. However, the machine is convenient and much more easily utilizable than the chemical hygrometer, although nowhere near as exact. Given N we have the ratio of the pressures of the unsaturated water vapor present in the air to the pressure of a saturated water vapor if it were present at that temperature. The pressure of the saturated water vapor at that temperature can be readily obtained from the steam tables, and hence the pressure of the saturated vapor can be obtained. Given the pressure and temperature of this unsaturated water vapor, the quantity present in a unit volume can be readily obtained also from steam tables. Thus the result obtained by this method is identical to that obtained by the chemical hygrometer. This is the result desired in all removals of moisture from air. Also the difference between this vapor and the quantity of saturated in the same space is what is desired as data for work in cooling-tower practice and ordinary drying devices.

This explains somewhat the situation as existing in hygrometry to-day. There are two distinct lines of application in this field, with different conditions holding for their best efficiency. Each of these developments is capable of great expansion. Thus, the removal of water vapor from air before its compression in the production of compressed air for power purposes, is eminently desirable and is sure to be a development of the near future. In the same way its further removal for drying purposes and for cooling-tower practice is not beyond the present possibilities. The removal of moisture in cooling-tower work by means of refrigeration seems a possible and an efficient process, since the cooling tower is often used in refrigeration work, but there is often a large amount of waste of refrigeration which can be used in this development. In general it can be said, as a result of study in this field, that air at the higher latitudes has less moisture per unit of volume than that at the surface of the earth. Thus it pays to take the blast in iron furnace work primarily from a place near the top of the furnace. This is just one of the number of possible interesting conclusions which can be drawn from a consideration of this department, and a large number of others at once become apparent to the engineering specialist who is at all familiar with work in this field. The developments in this line—that is, those dependent upon the removal or production of water vapor in the atmosphere—have just commenced, and will become more and more important with the lapse of time.

A Bird Stopped Gas Engine.

A rather strange solution to a puzzling difficulty was found some time ago at Nottingham, England, where a small gas engine had begun to show signs of working in an unsatisfactory manner. A machinist was sent, and on disconnecting the air suction pipe a small bird was found lodged in such a position that one of the wings had got under the gas valve, preventing it closing tightly. Apparently the grid at the mouth of the suction pipe had become displaced, and the bird, evidently of an investigating turn of mind, had got too close to the suction pipe and been drawn in by the inrush of air, carried round the bends and through the length of pipe till it lodged in the restricted area at the valve. Needless to say, the bird was dead when it was discovered to be the cause of the mischief. Instances have been known where experts have been called upon to make long journeys in order to investigate the reasons why gas engines did not start, and the trouble turned out to be that the gas was not turned on, but the above is a still more unusual cause for a gas engine not working satisfactorily to the user.—*The Gas Engine.*

Commutators should be of large diameters and ample wearing depth, and should have bars of hard, drawn copper insulated from each other and from the clamping ring by the best quality of mica, so as to give even wear. If the mica wears faster or slower than the bars, sparking will result.

The Boston Steam Turbine Electric Station

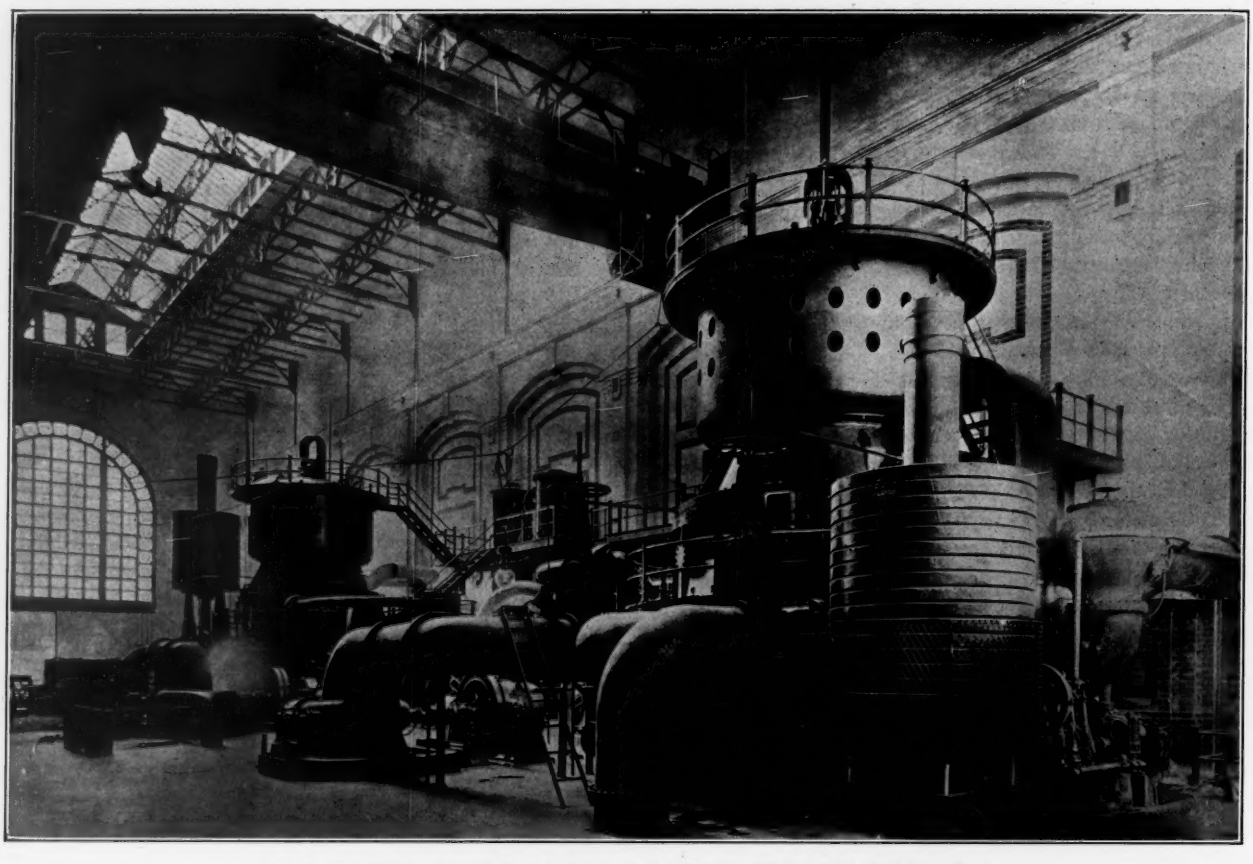
By Frank C. Perkins.

One of the most thoroughly up-to-date and interesting central stations in the United States is that of the Edison Electric Illuminating Company, of Boston, Mass., equipped with four-stage Curtis steam turbines, as shown in the accompanying illustrations. The new steam turbine station is located alongside the old plant, which is equipped with reciprocating engines of the compound type, the latter having been installed by the Boston Electric Light Company several years ago. The old plant includes a half dozen units of 1500 kilowatts each, vertical compound engines of the McIntosh & Seymour type being directly coupled to electrical generators of a combined capacity of about 9000 kilowatts.

of the turbo-alternator without the condenser being 230,000 pounds. It is stated that the total weight of each unit is 260 tons, which is about 4000 pounds or two tons per square foot of base.

The turbine station of the Boston Edison Illuminating Company was designed for a dozen units of 5000 kilowatts each, or a total output of 60,000 kilowatts, while the turbo-alternators installed have a maximum overload capacity of 50% for two hours without danger, so that the total peak load capacity of the station will be nearly 100,000 kilowatts when fully completed.

Each of the Curtis four-stage turbines has 15 sets of initial



5000 K. W. Turbines installed at Plant of the Edison Electric Co., Boston, Mass.

Each of the 5000-kilowatt turbine units consists of a four-stage Curtis steam turbine operating at a speed of 514 revolutions per minute and directly coupled to a General Electric three-phase alternator supplying a current of 6600 volts pressure and a frequency of 60 periods per second. The turbines are mounted upon especially designed surface condensers which form the base of the turbine structure, as noted in the accompanying illustrations.

The revolving field of the alternator mounted on the top and forming the upper portion of this 5000-kilowatt unit, is nearly 9 feet in diameter and weighs nearly 35 tons, the total weight

nozzles on each side, with three rotating discs, each carrying two sets of blades, the turbine wheels each having a diameter of about 13 feet. To each of the nozzle chests of the turbines is connected a 10-inch pipe connecting with a 15-inch steam main, and no exhaust pipe is necessary, as the turbine is mounted directly upon the condenser, as mentioned above, and there is an automatic release valve arranged for discharging into a free exhaust main 2½ feet in diameter.

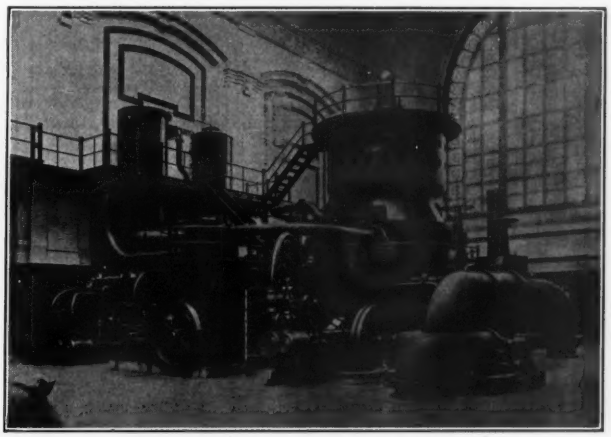
The turbine station is constructed on the unit plan, each pair of turbines being supplied with steam from its own bank of boilers arranged in four batteries of two boilers each of 513

h. p. capacity for each turbine unit, as well as the necessary condensing and other auxiliary machinery required. The boilers each have a heating surface of 5118 square feet, with a grate area of 110 square feet, measured on the inclined plane of the stokers, and a superheating surface of 867 square feet. These boilers have tubes 18 feet long, 14 tubes high and 18 tubes wide, and the steam pressure carried is 175 pounds per square inch, with steam superheated 150 degrees.

The total length of the boiler house and turbine room will be, when completed, 640 feet, the boiler house being 150 feet wide, and the turbine room nearly 70 feet in width. Each pair of turbines, forming a group, with its boilers and auxiliary equipment, is provided with a separate chimney, there being six chimneys designed for the completed station, of 90,000 horse power capacity.

The coal is brought by boat to the wharf at the power station, which is provided with two towers, equipped with buckets of one and one-half tons respectively, delivering the fuel to a belt conveyor which conveys it to a bridge 60 feet high, with a span of 155 feet and 82-foot cantilever. This allows a distribution of the fuel, with ground storage of 140 million pounds of coal, forty million pounds being under the trestle, with a bunker capacity of one million pounds near the old plant.

A two-ton bucket is used on the bridge for delivering the coal to conveyors serving the boilers, these conveyors being also loaded at the tower when desired. An individual coal-hopper is arranged for each boiler capable of holding 88,000 pounds of fuel or sufficient for nearly two days' operation,



5000 K. W. Curtis Turbine and Auxiliaries at the Plant of the Edison Electric Co., Boston, Mass.

allowing 20 pounds per square foot of grate. The accumulator is 6 feet 9 inches diameter outside of weights, which may be noted in the illustrations, together with the circulating water pump, vacuum air-pump and other auxiliary apparatus.

DISTRIBUTION OF ELECTRIC CURRENT

Constant-Current, Constant-Potential, Series and Parallel Circuts

There are two systems of electric distribution—the constant-current and the constant-potential systems. In the constant-current system there is always a current of the same intensity flowing through the circuit and the voltage of the generator must rise and fall as the resistance of the circuit varies under different conditions. In the constant-potential system the voltage is always kept as near constant as possible and the amount of current may vary from zero up to the capacity of the generator or generators.

Constant-Current System.—As all lamps require a constant current, they can be connected either in series on a constant-current system or in parallel on a constant-potential system. When a constant current is used, the distributing mains form a simple closed circuit, and when the lamps to be lighted are thrown off and on the circuit, the voltage of the generator will be lowered and raised in proportion to the voltage which the lamp takes up. As the lamps of all constant-current systems are connected in series, a constant-current system is also called the series system.

In the series system, the capacity of the wire in the circuit need be only that which is necessary to feed one lamp, as all the lamps in the series require the same current. The system is simplicity itself, as shown in Fig. 1, its principal objections being that each lamp in the circuit must take the same current; the voltage becomes very high as the number of lamps increases, and for house lighting individual lamps cannot be extinguished because this would affect all others in the series, unless a resistance equal to the lamp be substituted in the circuit when it is extinguished. This latter method is impractical if the number of lamps is large.

In arc lighting, fifty to one hundred lamps may be placed in one circuit which may be several miles in length; each lamp requiring ten amperes of current and a drop of potential of fifty volts.

Series Incandescent Lamps.—If incandescent lamps are used on arc light circuits, they must have thick filaments so that there will be a comparatively potential difference across its terminals. If fifty incandescent lamps are connected in series it would require 5500 volts to drive one-half an ampere through them. In practice, for outdoor lighting, a 10 ampere, 100 candle power lamp is standard.

All lamps used in series lighting should be equipped with an automatic cut-out so that if the lamp should become broken, the current through the circuit should not stop. Should a lamp become broken, all the electro-motive force of the circuit becomes active at the broken terminals. Advantage is taken of this fact by dividing a circuit through a series lamp into two paths, one path going through the filament, and the other path going to two terminals within the lamp between which is interposed a piece of paper. Under ordinary conditions, the current passes through the filament, but should the filament break, the voltage due to the electro-motive force of the system will pierce the paper and the two free terminals will come into contact, thus re-establishing the circuit. This, however, will cause an increase in current in the system, but the station attendant, recognizing the increased current, will throw one of the relief

lamps, provided for the purpose, in the circuit, thus establishing normal conditions until the broken lamp can be replaced.

Along many trolley lines, where the potential is 550 volts, five ordinary incandescent lamps are used in series to do the lighting of the road; the interior of street cars are also lighted in the same manner. This method is open to the objection

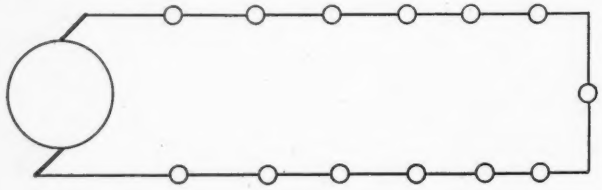


Fig. 1.

that should one light burn out, the other four lamps will be cut out.

Constant-Potential Distribution.—For all interior lighting the constant-potential distribution is used because perfect independence of all the lamps is established, the maximum difference of potential is harmless and the electric energy utilized is proportional to the number of lamps lighted. The general voltage used is one hundred and ten volts, and as each lamp of 16 candle power requires one-half ampere, the resistance of the filament is 220 ohms.

The most simple case of parallel distribution is where two wires of the same thickness are carried through the district to be lighted and to have them of such size as to carry current enough to light the required number of lamps. This, however, is too expensive a method in practice, as the total current at the dynamo determines the size of the wire, while near the far end of the circuit, where only a few lamps are carried, a much smaller wire could be used.

The size of a conductor is determined first by the amount of current it can carry without undue heating, and secondly the drop of potential allowable for economical lighting; the second condition usually being the determining factor, as the first condition will be met when the second condition will be fulfilled.

In the design of a distributing system, great care should be taken to obtain a good distribution of potential, as a variation of from one per cent. from the normal voltage means a considerable difference in the illuminating power of the lamp. In general terms, it may be stated that the drop of potential of one volt in a 110-volt 16-candle power lamp will reduce the

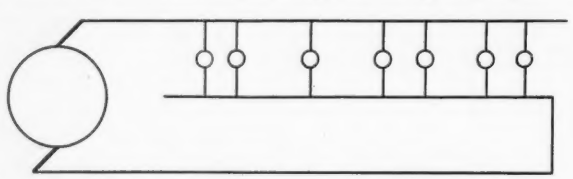


Fig. 2.

candle power to 15 candles. All calculations for finding the size of wires are based upon Ohm's law and can best be worked out by allowing a certain predetermined drop before calculation. Feeders, mains and leads are thus all calculated separately.

Systems of Parallel Distribution.—There are various systems of distribution that are used in practice, among which may be mentioned the loop system, the tree system, the closet system, the anti-parallel system, three-wire system, etc. The loop system is shown in Fig. 2, which is arranged so that the current for each lamp goes through the same length of wire. While uneconomical with copper, it can be made to furnish a steady potential. Another used is the closet system, which arranges a number of lights in groups, each group having its own feeders. Fig. 3 shows a symmetrical arrangement, which in practice is irregular shaped. This method is used in interior wiring, and the length of the main for each lamp is the same. The tree system merely consists of one set of feeders from which branches are led to the different lamps and is so named because the diagram of such a system resembles a tree.

Three-Wire System.—The amount of light furnished by an electric lamp is directly proportional to the energy in the electric current that passes through it, and the amount of power delivered by an electric motor is also proportional to the amount of electrical energy in the current that operates it. The voltage of the current determines the ability to overcome the resistance that opposes its flow through the circuit, just

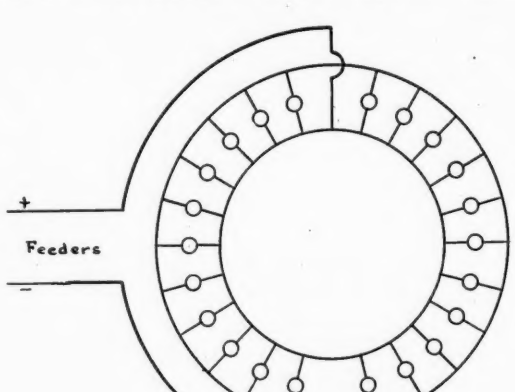


Fig. 3

the same as pressure in steam and water indicates its ability to force its way through the pipes. Voltage, in fact, is the equivalent of pressure. The amperes measure the amount of current that passes through the circuit. The energy value of an electric current is equal to the products of the volts by the amperes and is expressed in watts. Thus if a current of ten amperes is flowing through a circuit, and the voltage that forces it along is 100 volts, then the energy will be the product of 10 amperes by 100 volts; or, in other words, it will be 1000 watts. If the current is 20 amperes, and the voltage 50, the watts will still be 1000, for 20 times 50 equals 1000. The size of wire required to carry a current is dependent upon the amperes, and not the volts. Thus, if a wire can carry only 10 amperes when the voltage is 20, it can carry but 10 amperes when the voltage is 20,000, or any other amount. If the voltage is 20, and the amperes 10, the power will be 200 watts, but if the voltage is increased to 2000, which is one hundred times as great, we also increase the power-transmitting capacity of the current one hundred times, and this we accomplish without increasing the size of the wire. From this illustration it will be understood at once that to transmit power by means of electric current with the greatest economy, we have to use

the highest voltage admissible. Thus for incandescent lights, the voltage of 110 is generally provided. The current required by a 16-candle power incandescent lamp of 110 volts is about one-half of an ampere. If lamps could be used that would require 220 volts, then the current strength would be reduced to about one-quarter of an ampere; hence, with the same size

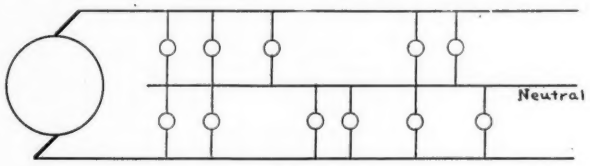


Fig. 4

wire twice as many lamps could be fed. While 220-volt lamps are made, in the great majority of cases 110-volt lamps are still in use. With these 110-volt lamps, as great an economy in the use of wire as we could by using 220-volt lamps by adopting what is known as the three-wire system of distribution. This system, briefly explained, consists in so arranging the lamps that the current passes through two in series, instead of one, and, as each lamp requires a voltage of 110, the two combined will balance a current having a pressure of 220 volts. A three-wire system connected to one generator is shown in Fig. 4. A potential difference of 220 is maintained between the two outside wires; the third wire lying half way between the others in potential. This wire is called the neutral wire. The outer conductors are generally made one-half the size of those in the two-wire system for the same load, and the neutral wire is generally made one-half the size of the outer conductors. If there were always the same number of lamps on either side of the wire, the neutral wire could be dispensed with. If, however, all the lamps on one side were lighted, and all on the other were extinguished, the neutral wire would have to be as large as the outside wire. In large distributions this is seldom the case, the aim of the central station manager being to always balance the load whenever possible.

The most usual arrangement of the three-wire distribution is shown in Fig. 5. Two 110-volt generators are connected in series, which makes the two outside wires carry a difference

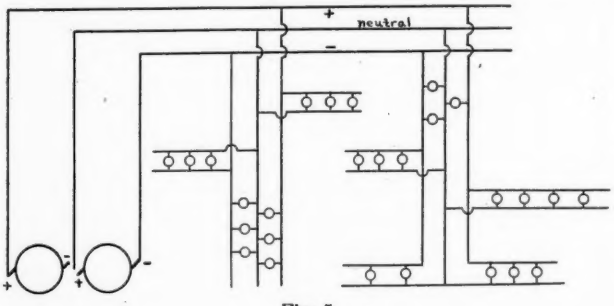


Fig. 5

of potential of 220 volts, the 110-volt difference of potential being obtained between one outside wire and the neutral. In practice, so as not to disturb the balance of the load on either side of the circuit, motors of any appreciable size are made to run at 220 volts and are carried across the outside mains, the lighting load being divided between the two sides as nearly as possible.

A new form of three-wire generator shown in Fig. 6 has been recently introduced into the engineering field for the purpose of replacing the usual methods of operating the three-wire systems. It is the same as the standard single-voltage machine, except that additional leads from the armature windings are connected to collector rings mounted on the armature shaft. This arrangement is exactly similar to that employed for the alternately current side of the armatures of rotary converters. This arrangement is of the two-phase type and across the two-phase collector a pair of auto-transformers or balance coils are connected, as shown in the accompanying diagram. These balance coils have a single winding about a laminated iron core of the shell type and are immersed in oil and mounted in cases similar to the transformers. The mid-points of the balancing coils are interconnected and from this connection is led the neutral of the three-wire system. This

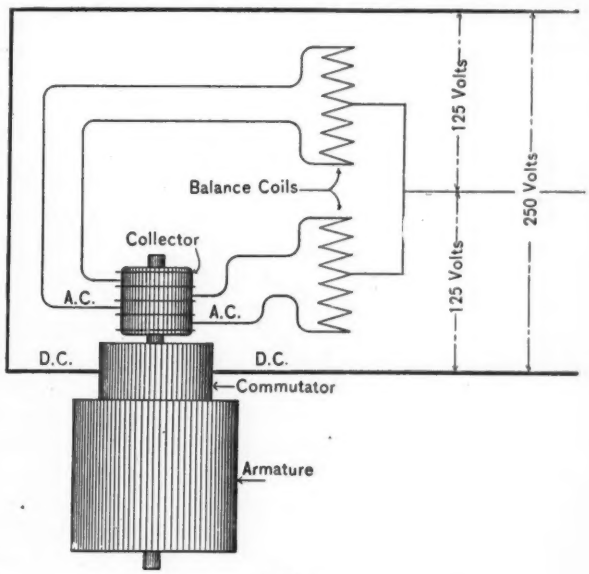


Fig. 6

type of generator is said to have its best application in the distribution of electric light and power in office buildings. There are also numerous three-wire systems in use which use storage batteries for regulation, both with and without an equalizer. For large systems, a balancing dynamo, or a motor and booster are used for maintaining the proper voltage on each side of the circuit.

The growing demand for direct current electric motors that can be applied to the individual drive of machinery of various kinds has led to a number of important changes in both the mechanical and electrical design of the motors heretofore used. To meet the requirements of this service the construction should not only be compact, but also permit of mounting the motor in any position, while the windings and commutator must be either partially or wholly protected from external injury. Geared and direct-coupled methods of driving are rapidly displacing belts, and this, together with the fact that sudden and excessive overloads are of common occurrence, requires larger bearings and shafts of greater stiffness than were formerly used in motors of the same class. The demand for a wide variation in speed by shunt field control, with occasional heavy overloads at any speed, has also called for material improvement in commutating qualities.

COMPOUND GENERATORS IN PARALLEL

By S. A. Fletcher.

The operation of direct current generators in multiple has now become so common an occurrence that little thought is given to the matter. Yet to many a man it is far from a simple matter to parallel compound generators and make them divide the load as they should. Even old stagers may find a few points here that have not been fully understood.

To make the matter clearer, let us consider the simplest case possible, the parallel operation of two shunt machines. These are connected in multiple with positive terminals together and negatives together. Then the load is properly shared between them by adjustment of the field rheostats. If the main line voltage is too high or too low, the rheostats on the two machines are adjusted simultaneously. Such a case presents no difficulties whatever.

With the addition of a series field for the compound generator, difficulties may begin. The series coil makes the generator able to generate more voltage, or a constant one, as the load increases. This means that if the same connections were made as with the shunt generators, one generator or the other would take all the load. The increase of current would increase its voltage and make it take more and more current, until its mate was taking practically none or even running as a motor. But the addition of the equalizer bus bar puts the situation back to the shunt generators again. Reference to Fig. 1 will make this clear. This illustration shows two generators, A and B, of equal size in parallel. The shunt fields are shown at *s* and *s'* with the fine coils. The series fields are shown by the heavy coils between *a* and *c* for A, and *b* and *f* for B. The main bus bars, positive and negative respectively, are marked and connect to the generators as shown. The connection between the positive (+) brushes of A and B, between points a and b through switch E, is the equalizer bus. It puts A and B in the condition of shunt generators, and also puts the series fields in multiple. The result of this connection is that if one generator tries to take too much load, some of its current will flow through the equalizer to the other generator's series field and causes the voltage to be built up. This then prevents either machine from carrying all the load. Hence, in connecting these machines together, switch E must be closed first, then either or both the others after the voltages and polarities are found to be correct.

Fig. 1 does not show any ammeters or circuit breakers, though the main switches are given at M and M'. These would be placed on the negative side, that is, on the side opposite the equalizer. The equalizer may be on either positive or negative side, but the ammeters and circuit breakers must be placed on the side opposite to the equalizer. This means here for A between *h* and *g*, for B, between *l* and *k*. This is necessary for the ammeters that they show the currents actually flowing in the armature, irrespective of whether there is current in the equalizer; for the circuit breakers, that when they operate, the armatures may be disconnected from each other and not left in multiple as would be the case if the circuit breakers were on the same side as the equalizer. Leaving the armatures in multiple with one machine disconnected from the main circuit might readily allow it to be run as a motor by its mate.

Before these generators are put in parallel, they must be adjusted for the same degree of compounding by means of the German silver resistance coils in multiple with the series fields. These are shown in Fig. 1 at S and S'. It is seen that these coils are in multiple with their respective fields. A change in the resistance will cause more or less current to flow in these and hence vary the excitation produced by the series field, and therefore vary the voltage under load. This adjustment is made at the factory ordinarily and does not have to be done by the purchaser.

After the generators are paralleled, the current will divide between them in some proportion. As the two machines are the same size, each should take half the current. They very likely will not do this without adjustment. What shall this adjustment be? The first thought is to vary the shunt field resistance as was done with the shunt generators. This is a possible, though not a good way. The objection is that it causes current to flow in the equalizer one way or the other and therefore tends to defeat the object of the equalizer if fluctuations occur in the speeds of the generators. Also, it will not give an equal distribution of load at all currents and is also liable to produce sparking at different loads. Hence, it is not satisfactory. Another point of adjustment might readily be thought to be the resistance coils in shunt with the series field coils. If these were adjusted before the generators were in parallel, why not afterward? A little thought shows that the two shunt resistances are put in multiple with each other as well as with the two series fields. Hence, any change

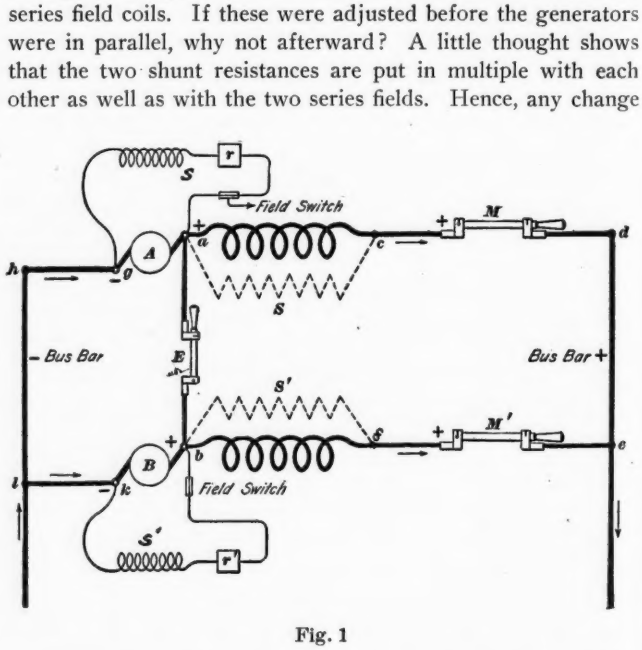


Fig. 1

affects each equally, that is, it merely changes the current in each series field by an equal amount and does not in any way produce the desired result. What is this desired result? A change in the current in the series field of one without a similar change of the current in the other. Evidently, then, lowering the resistance of S would cause more current to flow in S

or less in both series fields. This would reduce the voltage of both generators and not that of A only. Hence, this method is ineffective.

The only effective method is to place a resistance in series with the series field of one generator. This will increase the drop through that series field and hence make that generator voltage less at the bus bar. This, then, decreases the current the generator takes and hence decreases one field and strengthens the other. This is then the desired result, for weakening one does not weaken the other, but rather strengthens it.

Refer again to Fig. 1, and suppose A takes 600 amperes and B but 400 when they are paralleled. Both evidently should have ½ of the total or 500 amperes. Evidently A is taking too much load, and therefore its field strength must be reduced. Therefore, a resistance must be inserted in series with its series field between *c* and *d*. This slightly reduces the voltage of A at the bus bars by increasing the drop.

The proper condition is that the drop from *a* to *d* shall equal that from *b* to *e* when equal currents are flowing. This means, then, in this case equal resistances from *a* to *d* and from *b* to *e*. These may be readily measured by an ammeter and a low reading voltmeter. The 5-volt or 15-volt scale on the 150-volt meters will do for this work. The drop shown by the voltmeter divided by the current of the ammeter gives the resistance, for by Ohm's law we know the voltage divided by the current gives the resistance. The resistance for each machine is measured and the difference between them shows the amount which must be connected in series with the smaller resistance.

Returning to the case already mentioned, where A takes 600 amperes and B but 400, suppose we measure the drop *a* to *d* and find it to be 2 volts. The drop *b* and *e* shows 2 volts also. Hence, it follows at once that the resistance for A is $2 \div 600 = .003333$ ohms, and for B $2 \div 400 = .005$. Evidently the resistance for A must be increased to .005 by adding .001667 ohms. It should be inserted between *c* and *d*.

It is to be noted that in taking these measurements the machine ammeters cannot be used unless the equalizer switch is open. As it is unsafe to run both machines with E open, the machine ammeters can be used only at a time when the generators are not in parallel. The machine ammeters cannot be used when the generators are in parallel because current may be flowing in the equalizer and hence the currents in the series fields may be very different from the currents shown on the ammeters. It is perhaps better to use one instrument and connect it first in series with A and then with B, first between *c* and *d* and then between *f* and *e*.

Now that we have found that a resistance of .001667 ohms must be inserted between *c* and *d*, let us find what will be used. It evidently must be some form of cable having as great a current-carrying capacity as the machine will be called upon to deliver. Let us suppose the load which the generator can stand is 750 amperes. Then our cable must carry 750 amperes without overheating. By reference to a table of carrying capacity for stranded cables, we find that this will require a 700,000 circular mill cable. Such cable has a resistance of approximately .01478 ohm per 1000 feet. Hence, it would require $\frac{.001667 \times .1000}{.01478} = 113$ feet of this cable. This means a considerable outlay for copper, but is necessary if the machines are to divide the load correctly at all loads.

Suppose instead of having two equal generators we have two unequal in size. The currents then must divide between the machines in proportion to the kilowatt capacities. As before, the drops across the series coils and their connections must be equal. Refer to Fig. 2, where A and B represent machines of different size. A is a 300-kilowatt generator and B a 100. Hence, the current taken by B must be only 1/3 that taken by A. This means, then, that B takes ¼ of the total

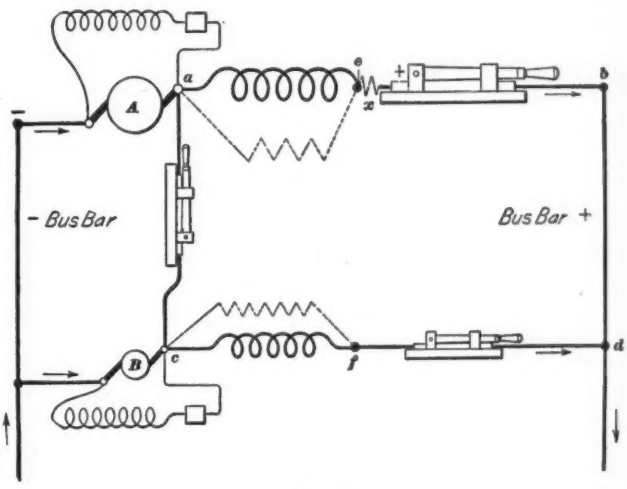


Fig. 2

current, and A, ¾. But it is found that A takes 800 amperes and B 200 amperes. Evidently the total current is 1000 amperes and B should take $\frac{1000}{4} = 250$ amperes and A, 750. A is taking too much. A measurement of the drop shows 2 volts from *a* to *b* and 4 volts from *c* to *d*. Hence, the resistance from *a* to *b* is $2 \div 800 = .0025$ ohm, and from *c* to *d* is $4 \div 200 = .02$ ohm.

Evidently these resistances should not be equal, but must be in inverse proportion to the currents. That is, the current of A should be three times that of B, and therefore the resistance of B should be three times that of A. This is in order to fulfill the condition that the drop from *a* to *b* shall equal that from *c* to *d* when the correct currents flow. Evidently, then, the resistance of B should be $3 \times .0025 = .0075$ ohm. As it is .02 ohm, the resistance of A must be increased until it is 1/3 of B. Therefore, A should be $\frac{.02}{3} = .00666$. Hence, there must be inserted between *e* and *b* at X a resistance equal to $.00666 - .0025 = .00416$ ohm. The size of cable and length would be found in a manner similar to that used in the first example.

By such adjustments as these, after the generators are installed, they are made to divide the load in proportion to their capacities. It is called compounding the station as a whole.

Motors which are totally enclosed are dust and moisture-proof, but this shuts off the ventilation so that the output of a totally enclosed motor is less than an open-type motor of the same size.

Practical Design of the Centrifugal Pump

By R. Davis Mumford.

The name centrifugal pump to most people merely means a machine which has something inside of it which is turned around at a certain speed, and the liquid is discharged at a pressure.

Although this crude description fits a centrifugal pump exactly, a very few really do know how a centrifugal pump is designed and operated. The word "centrifugal" means from the center, thus the name of the pump, as the liquid which is to be pumped is led into the center of the impeller or runner and is thrown toward the periphery of the runner.

When the liquid leaves the impeller it passes into the pump-casing or volute, and from the pump-casing the liquid goes through the discharge pipe to the proper location.

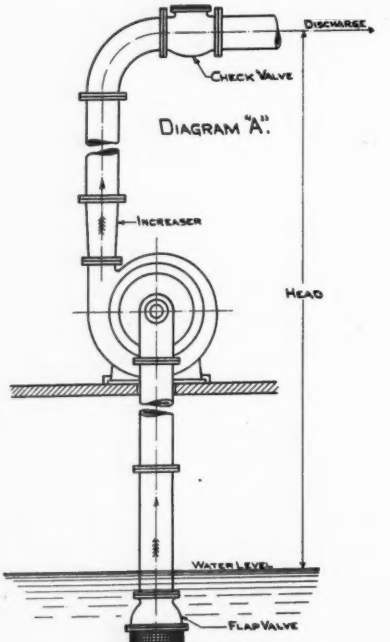


DIAGRAM "A."

The following formulas and diagrams have been collected by experience and put to practical use, and have been found to give very satisfactory results.

The most important part of the centrifugal pump lies in the designing of the impeller, and, therefore, has the most consideration. The first things which have to be known are how high the water has to be pumped or lifted, and is called the *head,* and is measured according to diagram "A;" the capacity of the pump in gallons per minute, hereinafter referred to as G. P. M.; and last, the revolutions per minute of the driving power, hereinafter referred to as R. P. M.

From the capacity of the pump in G. P. M., the diameter of the discharge pipe can be calculated. The size of the pump is always known by the diameter of the discharge pipe, thus an 8" pump would mean a pump with an 8" discharge opening in the volute. In calculating the diameter of the discharge opening a velocity of from eight to ten feet per second is considered most economical, although some manufacturers allow a velocity as high as twelve and fourteen feet per second.

Referring to diagram "D," the circumference of the impeller in feet is found by the formula:

$$\frac{\sqrt{\text{Head}} \times 480 + \text{M}}{\text{R. P. M.}}$$

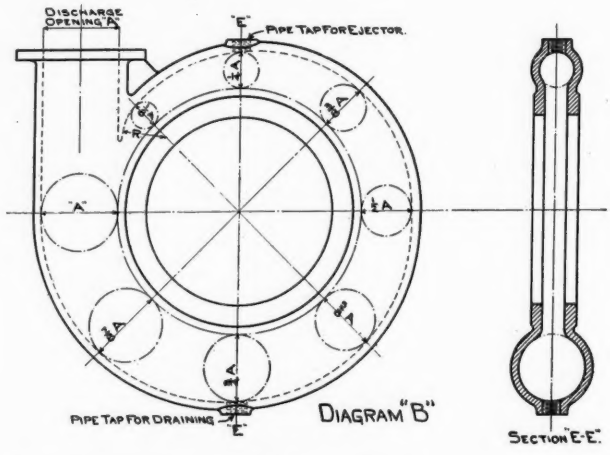


DIAGRAM "B"

In the above formula "M" is equal to—

$$\frac{\text{G. P. M.} \times 231}{\text{Area of Discharge Opening} \times 12}$$

The opening "a" is equal to—

$$\frac{\text{Circumference of Impeller in Inches}}{\text{Area of Discharge in Inches}}$$

The opening "b" is equal to the area of the discharge plus the area of the shaft.

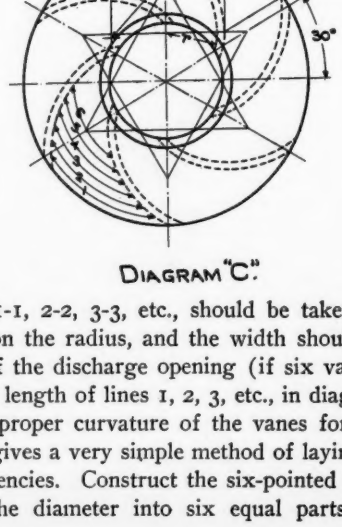


DIAGRAM "C."

The areas 1-1, 2-2, 3-3, etc., should be taken about every quarter inch on the radius, and the width should be equal to $^1/_6$ the area of the discharge opening (if six vanes are used) divided by the length of lines 1, 2, 3, etc., in diagram "C."

To get the proper curvature of the vanes for the impeller, diagram "C" gives a very simple method of laying out a curve for good efficiencies. Construct the six-pointed star as shown by dividing the diameter into six equal parts and connect

points as shown and using intersecting points as centers for radii.

The area of the suction pipe should be made about 20% larger in area than the discharge opening, to prevent any liability of choking.

The shaft diameter can be figured for torsion, using any good formula.

Next to the impeller in importance comes the volute or pump-casing. The areas through this snail-shell looking casting will be found by referring to diagram "B," in which "A" is equal to the area of the discharge opening. By finding these areas at the different points the diameter at that point can very easily be calculated.

The side plates, suction elbows, bearings, etc., can then be made to suit conditions, the judgment of the designer being brought into play for the thickness and clearance of rotating parts.

Before a centrifugal pump can be put in operation the pump-casing and suction line have to be filled with the liquid to be pumped. This is done by drawing all the air out of the casing and suction line by means of an ejector placed on top of the volute and operated by steam, water under pressure, or as in some cases, by means of an ordinary hand air-pump.

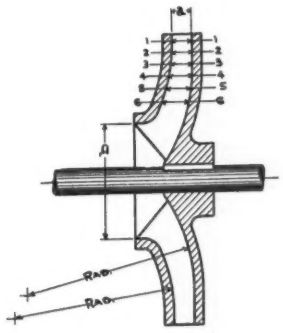


DIAGRAM "D".

ARITHMETIC FOR ENGINEERS

Addition, Subtraction, Multiplication and Division of Common Fractions.

By E. S. Hawkins.

PART IV.

Arithmetic, ordinarily called the Science of Numbers, may be better defined perhaps as the Science of Measures, for numbers are used only to measure quantity or quality, as 100 pulleys, 100 per cent. fine. They tell how much or how many, of the things they are used to describe, whether valves, cement, heat, volume or pressure. All of the many systems of measurement in use have one quality in common. Each one breaks the thing to be measured into parts. A quantity of coal is divided into tons. An indiscriminate heap of screws is found to be made up of dozens, and so forth. This breaking up of an indefinite quantity into certain definite smaller quantities is called analysis. The joining together, or counting up of these parts is synthesis, as, 6 tons, 7 dozen. The process of anaylsis and synthesis is, from the nature of the case, one of parts or Fractions.

The word Fraction comes to us from the Italian and is present in our language in various forms, all different, but related in meaning. When an arm is broken there is a fracture. A horse breaks from under control and is said to be fractious. The word combined in many ways carries with it always the idea of breaking away from or breaking up; and is found to be quite pertinent when we recall the timeworn phrase, "A Fraction is any part of a whole."

The theory of fractions, although given a prominent place in arithmetical study, is not usually considered in its broadest sense; nor is its paramount importance in relation to integral quantities realized. Based upon and bound up in integral quantities, fractions are at once the underlying principle of most of our numerical ideas. Any fractional expression contains two parts or terms which are written above each other with a line between which means, "divided by." The number below the line tells into how many parts the unit has been divided and, as it points out or names, it is called the denominator. The other term, which tells how many parts of the unit are in the fraction, is called the numerator, being derived from a root meaning to number.

Although we seldom or never think of it, every whole number has in reality a denominator or measurer of its own. Suppose, for instance, that one says 14 valves, We know that 14 units of a certain kind, called valves, are referred to, so that 14 may properly be written over 1 = the unit. Suppose, again, that a valve is able to stand a pressure of 100 pounds. Here the unit of measurement is 1 pound and we realize that it has been taken or repeated 100 times, so that the amount of pressure may properly be expressed by 100 written over one. Taking the case of a defective valve, it may possibly not be able to stand more than $\frac{5}{8}$ pound pressure, so that the unit of measurement here cannot be one pound, but is $\frac{1}{8}$ pound, there being 5 of these units required to make up the whole quantity. Both one pound and $\frac{1}{8}$ pound are thus used to measure quantity, and $\frac{5}{8}$ pound is a fraction, being compared, as it is, with the unit, one pound, from which it is derived. At the same time 100 is a whole number when compared with the same measuring unit of one pound, but does not necessarily remain a whole number when compared with another standard.

We see, therefore, that the same principle underlies both fractions and integral numbers and that, to get a full realization of their values and relations, we should always be able to see them as fractions relatively expressed. A difference between the two is noted, however, in the fact that a fraction combines within itself the two ideas of multiplication and division. The multiplication is actual as, in the example above, $\frac{1}{8}$ was taken 5 times. In considering the indicated division, it will be seen that the numerator is really a dividend and the denominator a divisor. In other words, instead of 5 times $\frac{1}{8}$ pound, the fraction is taken as being 5 pounds divided by 8, but as $\frac{1}{8}$ of 5 pounds is $\frac{5}{8}$ of 1 pound, the fitness of the

fraction for expressing partial quantities is demonstrated, for, on carrying out the division, the fraction itself is found to be the quotient.

A number expressed fractionally usually contains only certain parts of one whole number, for example, a smaller quantity than unity or one whole thing, and is, therefore, called a proper fraction. It may be, however, that there are several whole like units which are divided similarly and their sum placed over a denominator, thus making a fraction larger than unity, which is just the opposite of a proper fraction and is therefore called improper. An improper fraction may readily be changed to a whole number and a fraction, when it is called a mixed number because it combines a fraction and a whole number. Suppose, for instance, that we have 39/12 foot. Carry out the indicated division, making 39 the dividend, 12 the divisor, when the quotient will be found to be the mixed number $3\ ^{3}/_{12}$.

In the discussion of the nature of integers, it was seen that an integral quantity could be changed to a fraction at will and it may be added that it can also be given any denominator. Suppose, for instance, that it is desired to find how many 16th yards there are in a 3-yard line. In one yard there are 16 sixteenths and in 3 yards there would be $3 \times 16 = 48$ sixteenths. We find, then, that, to reduce a whole number to an equivalent fraction, having a given denominator, the numerator of the fraction must be the product of the whole number by the denominator.

The four fundamental operations of fractions are identical with the similar operations with integers. In order to be added, integers must be alike, and the same is true of fractions, thus 6/9 and 7/16 cannot be added directly, as the result would be neither 9ths nor 16ths. Before these fractions can be added they must be reduced to equivalent fractions which have like denominators, the common denominator in this case being $9 \times 16 = 144$, so that there will be 96/144 to be added to 63/144, the result being 159/144, which is seen to be an improper fraction. It will be noted that, in this case, the common denominator is large and is the product of the two denominators of the fractions to be added. If the first fraction had been 6/8 (the denominator 8 being contained twice in 16), the larger of the two denominators would itself be the denominator to which both of the fractions should be reduced. It is well to cast about and see what is the smallest number that will contain each of the denominators, of several fractions to be added, an even number of times. The smaller the number that contains the denominators, the simpler is the work of adding the fractions. The smallest number possible is called the least common denominator and is found by selecting some factor that will divide two or more of the denominators of the given fractions and dividing through by this number. The remainders are then divided by another factor in the same way if such a factor can be found. When finally there is no number that will divide any of the remainders, these remainders, with the different divisors previously used, are multiplied together and the product of all of them is the least common multiple of the denominators taken in the first place.

Having found the least common denominator of the fractions, the numerator of each fraction in turn is multiplied by the quotient obtained by dividing the least common denominator by the denominator of the fraction. The different products thus found with the numerators of the fractions are added together and the sum placed over the least common multiple of the denominators of the original fractions. The fraction thus formed is the sum of all the fractions that were to be added.

There are other methods of changing the denominators of fractions so that they will be alike, the principle of operation being the same in all cases. One method is to multiply each of the numerators by the product of all the denominators except its own and use the product of all the denominators as the common denominator. This is the method used above for adding the two fractions 6/9 and 7/16 and it will be seen that the rule fulfills the requirement that each of the denominators shall be contained an even number of times in the common denominator used for the fractions. This method is used where, as in the case just mentioned, the denominators of the fractions are prime to each other. That is to say, where the denominators have no common factor or number by which they may be divided. The method is also convenient in adding two fractions or a small number of fractions where the products to be handled do not run into large figures. As an example, suppose that the fractions 4/6 and 2/3 are to be added. Here 18 is the product of 6×3 and is used for the common denominator of both fractions. Then the product 4×3 of the first numerator and the second denominator gives 12/18 for the first fraction, while the similar product of the second numerator and the first denominator gives $2 \times 6 = 12/18$ for the second fraction, the result of the fractions added being 24/18 or 1 1/3 when the improper fraction is reduced to a mixed number in its lowest terms.

When it is required to add a whole number and a fraction, reduce the whole number to a fraction having the same denominator as the given fraction and add the two as two fractions. Also when a mixed number is to be added to a fraction, reduce the two fractions to a common denominator and add them, placing the whole number of the original mixed number with the fraction obtained by adding the two original fractions and thus obtaining a second mixed number as the result of the addition. To add several fractions and whole numbers, reduce the fractions to a common denominator and add them as in ordinary work with fractions, add the whole numbers separately and combine with the sum thus obtained the sum of the fractions, taking care to reduce the fractional sum to its lowest terms and, if it be an improper fraction, to a mixed number. The result of the final addition may be a whole or a mixed number, depending on whether or not the sum of the fractions themselves was a mixed or a whole number.

Subtraction of Fractions.—This process is peculiarly simple as, after mastering the addition of fractions, no new theories or methods must be taken up. Unlike fractions must be reduced to a common denominator as in addition of fractions and, this done, the lesser numerator is taken from the greater, and the remainder placed over the common denominator, when the work is done. In subtracting mixed numbers, subtract the fractions first and then take the difference of the whole numbers or, if the numbers are small, reduce each of the mixed numbers to an improper fraction and, after reducing the fractions thus formed to a common denominator, subtract them as in the case of ordinary fractions. If the numbers are so large that the first method is adopted and it turns out that the

fraction of the subtrahend is larger than that of the minuend, a unit from the whole number in the minuend must be added to the fraction, thus making it an improper fraction so that it will necessarily be larger than the fraction in the subtrahend. As an example, suppose that $4^2/_3$ is to be taken from $7^1/_3$, one unit is taken from 7 (thus leaving it 6) and added to the fraction 1/3 so as to give the sum 4/3, from which the fraction 2/3 in the minuend can readily be subtracted, giving $6^4/_3 - 4^2/_3 = 2^2/_3$.

Multiplication and Division of Fractions.—There are few things about these processes that may not be deduced from what has already been said regarding the similar processes with whole numbers and the properties of fractions. There is, however, one peculiarity about the multiplication of fractions that is not readily grasped until one thoroughly understands the idea of division involved in fractional quantities. In multiplying integers, except when a whole number is multiplied by 0, the product is always greater than either one of the two quantities multiplied together. This is not the case in the multiplication of fractions, except in the case of the improper fraction, which indeed is not properly a fraction, since it involves a whole number. A quantity when multiplied by a fraction is always reduced, since the effect of the multiplication is to divide the quantity by the denominator and multiply it by the numerator, which, except in the case just mentioned, is always less than the denominator, so that the net result is to divide the whole number. The operation of multiplication is performed by multiplying the whole number by the numerator of the fraction and dividing the product thus found by the denominator of the fraction, thus $3/5 \times 20 = 3 \times 20 \div 5 = 12$. In case fractions are to be multiplied together, multiply the numerators of all the fractions together and divide the product by the product of all the denominators of the fractions. Where there are a number of fractions and several whole numbers to be multiplied together, the whole numbers may be written in the fractional form by placing each of them over unity, and the process of cancellation, already explained, can be used to shorten the work. This process may also be used in multiplying the fractions even when no whole numbers are involved, provided there are factors common to the terms in the numerators and denominators of the different fractions. The cancellation is limited to the cancelling out of the common factors in the different terms, and when all the numbers in these terms are prime to each other there can be no further cancellation, even though several whole numbers remain. As an example of the use of fractions, suppose that an engineer in a plant burning 61 tons of coal a week, desires to know something as to the efficiency of a fireman who fired for two days on trial. One-tenth of the coal is used for purposes other than firing the boilers tended by the fireman, and the load was extra heavy during the days that he fired, so that he is to be made an allowance of one-sixth the usual amount burned to account for the extra load. The coal actually burned by the fireman is weighed and it is then necessary to determine whether or not he was wasteful in handling the fires. The amount of coal that would ordinarily have been burnt in the two days is, $2/7 \times 9/10 \times 60 = 15^3/_7$ tons of coal burned in the boilers under consideration. The fireman is allowed to burn $15^3/_7 + 1/6 \times 15^3/_7 = 15^3/_7 + {}^{16}/_7 = 18$ tons of coal, and if the actual amount measured was 20 tons, he wasted 2 tons or 1/9th the amount that should have been burned.

In general it may be said that a fraction is multiplied or divided by a given number by performing the required operation on the numerator of the fraction or the reverse operation on the denominator. Thus to multiply, we multiply the numerator or divide the denominator of the fraction by the given number and to divide the fraction we divide the numerator or multiply the denominator. The same principle holds if one fraction is to be divided by another. Suppose, for instance, that 2/3 is to be divided by 1/7, we will take the numerator 2 and divide it by the fraction 1/7, thus performing the operation of division as in whole numbers. To do this division, we multiply 2 by 7 and divide the product by 1, placing the result over the denominator 3 of the fraction so that we have $2/3 \times 7/1 = 14/3 = 4^2/_3$, from which we derive the Rule: To divide one fraction by another, invert the fraction used as a divisor and then multiply it by the fraction to be divided. In this way the numerator of the divisor fraction is used to divide the numerator of the other fraction, while its denominator (the original dividing quantity) in the opposite operation of multiplying the numerator. Thus it is seen that the two terms of the dividing fraction preserve their identity throughout the operation, the one acting in the opposite manner to the other. In general, operations are performed positively on and by numerators of fractions and the reverse with the denominators of the same fractions. Adding a quantity to the denominator of a fraction decreases the value of the fraction, while adding to the numerator increases the value. Similarly, multiplying the denominator decreases, and multiplying the numerator increases the value of the fraction, while dividing the denominator or numerator acts in the opposite manner to increase or decrease the value of the fraction.

In all operations with fractions it is well to inspect the different terms of the fractions to see if they cannot be made smaller by dividing numerator and denominator, the corresponding terms, by the same quantity so as to make them smaller without changing the value of the fraction. In extended operations it is almost always possible to divide out some of the terms or to divide corresponding terms by common factors, thus performing cancellation or balancing off of like quantities, by which means the work is shortened. One must take plenty of space for the work where there are several fractions to be dealt with, so that the figures will not become confused, and care must be taken to strike out the quantities reduced or cancelled at the time of doing the operation so that the mind is not confused to remember which quantities have been dealt with. After reducing the terms the quantities left in the numerator are multiplied together to form a numerator, while the quantities in the denominator form a second product for the final denominator. When any given figure has been multiplied into the product it should be checked off so that there will be no danger of using the same figure twice in making up the product. Neglect of this caution is a prolific source of error, and if the computer is careless about crossing off the quantities dealt with, nothing but inaccurate results may be expected. When properly used the processes of reduction factoring and cancellation are the most useful of arithmetic. Any one can see that it is easier to multiply 6 by ½ than by $^4/_8$, for instance, and a number of more complicated illustrations could be given to point to the same lesson.

ANGULARITY OF THE CONNECTING ROD

How it Affects the Cut-off of an Engine

By Chas. J. Mason.

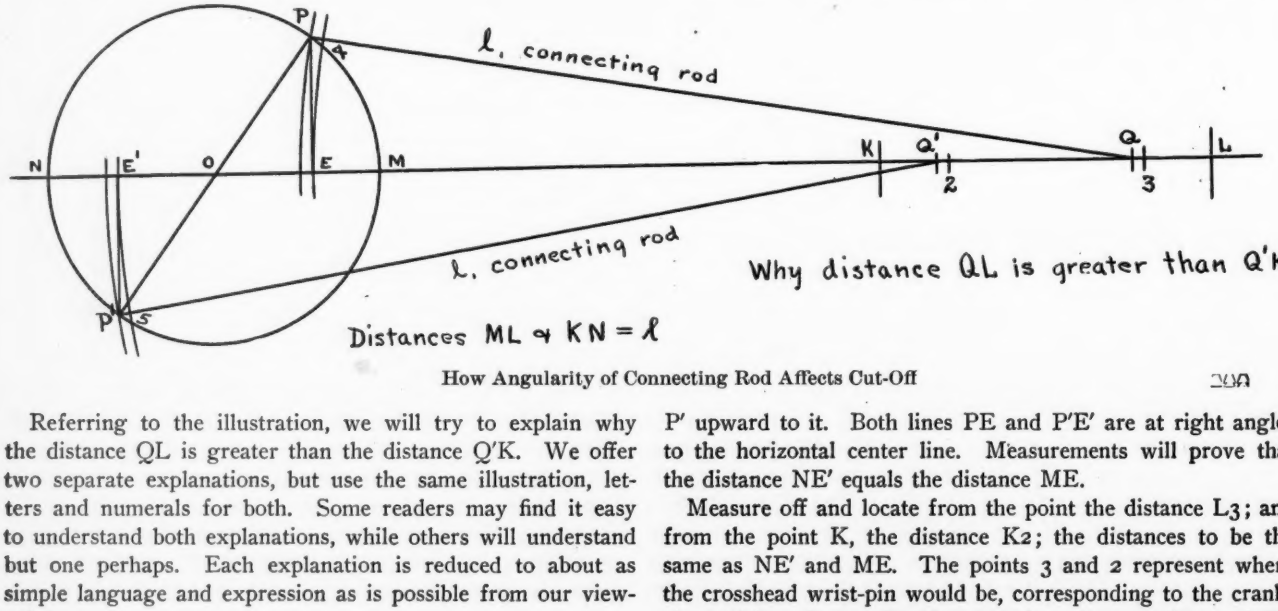
A study of the accompanying figure will show that because of the angularity of the connecting rod of a steam engine, the point at which the steam will be cut off at the head end of the cylinder will be later than that of the crank end. Why the difference exists occasions many a question, and some find it very difficult to understand why such difference should exist at all; but in reality it is a self-evident problem that requires but little thought expended upon it in order to arrive at an understanding of it.

If the connecting rod of the engine were dispensed with, and a yoke connection substituted, in which case the crank pin brasses slide back and forth while the crank revolves and the piston traverses its stroke, then there would be no difference in the point of cut-off. Of course, strictly speaking, the angularity of the eccentric rod also affects the question in the same way that the connecting rod does, but to a much less extent. It is too small to take any notice of in practice, and so we seldom ever hear of the effect of the angularity of the eccentric rod.

also chosen as a matter of convenience, as any other, within reason, of course, would do as well.

From the point M, which represents the head end center (referring to the position of the crank), measure off 5 inches on the horizontal line to the right, which locates the point L. The distance ML equals the length of the connecting rod. In the same manner measure off 5 inches from the point N, which represents the crank end center, and this locates the point K. The distance KL is the same as NM, 2 inches, and represents the crosshead and also the stroke of the piston, because both crosshead and piston move through the same distance.

When the crank-pin is on the crank end center at N, the crosshead wrist-pin is at K, and when the crank-pin is at the head end center M, the crosshead wrist-pin is at L. If it were not for the effect of the angularity of the connecting rod, the corresponding piston positions for the crank positions PO and PO′ would be E and E′, as found by projecting the point P downward to the horizontal line and the point



How Angularity of Connecting Rod Affects Cut-Off

Referring to the illustration, we will try to explain why the distance QL is greater than the distance Q′K. We offer two separate explanations, but use the same illustration, letters and numerals for both. Some readers may find it easy to understand both explanations, while others will understand but one perhaps. Each explanation is reduced to about as simple language and expression as is possible from our viewpoint.

In reference to the illustration, let O represent the center of the shaft and with it as a center describe a circle with a radius of, say, one inch. This radius is chosen as a matter of convenience, as any other figure would serve as well. The circle represents the path of the crank-pin of an engine. Draw the line PP′ through the center O and at any convenient angle to the horizontal line. PO and P′O represent the crank in two different positions diametrically opposite. The diameter of the circle which represents two inches, also represents and equals the stroke of the piston. Now make a choice of a connecting rod which shall be $2\frac{1}{2}$ times as long as the stroke, or $2\frac{1}{2} \times 2 = 5$ inches. This length is P′ upward to it. Both lines PE and P′E′ are at right angles to the horizontal center line. Measurements will prove that the distance NE′ equals the distance ME.

Measure off and locate from the point the distance L3; and from the point K, the distance K2; the distances to be the same as NE′ and ME. The points 3 and 2 represent where the crosshead wrist-pin would be, corresponding to the crank-pin positions P and P′, if angularity of connecting rod did not affect the case. By drawing the connecting rod as shown in the figure, using the given 5 inches length, it will be seen that instead of the crosshead wrist-pin being at points 3 and 2 respectively, as it should be in order to equalize matters, it will be respectively at Q and Q′; that is, the rod has been drawn away from the point 3 to point Q in order that the other end of the rod connects to crank P.

Now imagine the rod to be disconnected at P and allowed to swing to the horizontal center line, as shown by the arc; then the distance between where the arc intersects the horizontal line and the point E will equal the distance Q3. If the crosshead pin had remained at point 3 instead of having been

moved to Q, then the crank would have to be brought to the point where the arc intersects the crank-pin circle at point 4.

A careful study of the illustration and measurements of same will show that the crosshead wrist-pin, which also means the piston, must move from point 3 to point Q so that the other end of the rod will meet the crank. While it is true that the distance E3 is equal to the length of the connecting rod, so is the distance 4-3, but as the crank is at P, the rod must be drawn along to meet it, and as the length of the rod remains constant, the other end is the point Q. The same reasoning exactly applies to the crank position P′ and the distances KQ′ and Q′2, so there is no need to repeat the explanation.

After it is once understood that the distances Q3 and Q′2 must exist as explained, there should not be any difficulty in seeing that the end of the rod, as represented by the points Q and Q′ respectively, has been moved from the points 3 and 2 in a direction from the end of the stroke L and towards the other end of the stroke K; that is, both positions call for a moving of the rod in the same direction, so that of necessity, the L3 is increased to LQ and the distance K2 must be decreased to KQ′. It is to be remembered that K2 and L3 are exactly equal and it was known at the start that QL and KQ′ are not equal. By actual measurement it will be seen that the difference between QL and KQ′ is the distance Q′2 plus distance Q3.

The greater the ratio between the length of crank and length of connecting rod, the less will be the distance Q′2 and Q3 and the longer the crank with same rod or the shorter the connecting rod, the greater will become the distance Q′2 and Q3.

Another explanation which reaches the same result is shown as follows:

$$QL = EM + ML - EQ$$
$$Q'K = Q'E' + EN - KN$$
$$QL - Q'K = EM + ML - EQ - (Q'E' + E'N - KN)$$
$$QL - Q'K = EM + ML - EQ - Q'E' - E'N + KN$$

and since EM = E′N; ML = KN = l, the length of connecting rod; $-EQ - Q'E = -2EQ$, then

$$QL - Q'K = 2l - 2EQ = 2(l - EQ)$$

therefore, QL is greater than Q′K by twice the difference between l and EQ or, QL is greater than Q′K by the distance Q′2 + Q3.

The basic geometrical principle involved is, that the hypothenuse of a right angle triangle is greater than either of the other sides. The connecting rod represents the hypothenuse in its application to the problem.

STEAM AND LATENT HEAT

By E. D. Waller.

As the formation of steam is the first and most important step in the production of mechanical power, through the medium of the steam engine, the subject of steam and its properties cannot be too well understood. To judge from the writings of some of the authorities, the formation of steam within the steam generator is a most mysterious and imponderable subject, comprehensible only to the greatest professors of science, who have spent a lifetime in the study, and never have I seen in the writing any attempt made to explain why the greater portion of the heat contained in the steam is latent. Most all works on this subject simply state the fact that one pound of steam contains many times the heat contained in one pound of water at the same temperature; therefore the heat that is contained in this one pound of steam, which is not sensible, is latent heat, generally ending with the assertion that for some unaccountable reason this heat is insensible (therefore latent).

But, with a little study, any engineer can prove to his satisfaction that this subject of latent heat of steam is very simple and is not at all as mysterious as it is made to appear. As proof of the above statement, take for instance one cubic foot of air at atmospheric pressure (14.7 pounds per square inch absolute) and apply sufficient heat to raise its temperature to 212° F. (the boiling point of water), then allow this one cubic foot to expand to 1700 cubic feet (which is approximately the ratio of expansion of steam at 14.7 pounds), it will be found that the temperature will fall very low, while the body of air contains exactly as many heat units, but the space occupied is 1700 times as great, hence the fall in temperature or sensible heat. The above fact is amply proven by the fact that air in the same manner is used for refrigerating purposes. For instance, the heat necessary to raise the temperature of one pound of air from 32° F. to 212° F.= (212° — 32°); specific heat of air = 180 × .237 = approximately 42.66 B. T. U. Hence the temperature after being expanded 1700 times $= \frac{42.66 \text{ B. T. U.}}{1700} \div .237 = .106°$ nearly above 0° or .106° F.

Now if, as in the case of steam during expansion, the temperature (212° F.) is maintained, it will require an addition of heat of (212° — .106°), and since the specific heat of air is .237, the heat required will be 211.894 × .237 = 50.219 B. T. U. nearly. While the temperature remains the same, the pressure will fall 14.7 pounds ÷ 1700 leaving a pressure of approximately .0086 pounds absolute. In the expansion of water into steam the pressure (14.7 pounds per square inch) as well as the temperature is maintained.

According to the accepted meaning of the word latent, the term latent heat in regard to steam is correct, but considering the fact that the steam shows the same temperature as the water beneath it, while occupying 1700 times its original volume, the fact that the added heat has not raised the sensible heat or temperature is readily apparent and is not by any means unaccountable or mysterious. For instance, it requires approximately 965 B. T. U. to maintain the temperature of one pound of steam at 212° F. during process of expansion from water at 212° F. to steam of same temperature and 14.7 pounds pressure. Since the specific heat of steam is .48, it follows that the addition of 965 heat units would raise the temperature of one pound of steam as many degrees as .48 is contained in 965, or 2010.4, which added to 212° gives a temperature of = 2222.4°. As the specific heat

of water is one, and that of steam is .48, it would seem that each degree of heat given up by the water would raise the temperature of the same weight of steam as many degrees as .48 is contained in one, or, approximately, 2.185° F. Hence one pound of water at 212° F. would contain approximately 212 B. T. U., which added to 965 = 1177 B. T. U., which divided by .48 will give 2460.4, provided, of course, that the volume remained the same. That is to say, if one cubic inch of water were confined where there was absolutely no room for expansion, and heated to a sufficient degree to supply the necessary heat to produce a temperature of 212° F. after being allowed to expand 1700 cubic inches, or steam at atmospheric pressure, the temperature would necessarily be 1177° F., approximately. Again, if 1700 cubic inches of steam at atmospheric pressure were suddenly compressed to one cubic inch, without allowing any of the heat to escape, the temperature would be 2460.4° F. provided it retained the form of steam. But as it would depend upon being brought back to its original volume, it would necessarily assume its original form of water, and as the specific heat of water is one, the temperature would be 1177° F., approximately. To accomplish the above experiment it would require a pressure = 1700 × 14.7 pounds = 24990 pounds absolute or 24975.3 pounds gauge pressure.

Following the process of the formation of steam step by step, first we have a boiler or steam generator, filled with comparatively cold water, which immediately upon the application of heat begins circulation; that is, the particles which come in contact with the heating surface of shell or tubes, become lighter than the surrounding particles and begin to ascend, imparting their heat to other particles with which they come in contact. As the temperature of the furnace and water increase, the circulation become more rapid, until the boiling point (212° F.) is reached, when the particles of water in contact with the heating surface will be heated slightly above 212° and immediately begin to expand, forming small globules or bubbles of steam. When the heated particles begin to expand, their temperature falls slightly below that of the surrounding water, when the water will give up some of its heat to the bubbles of steam in an endeavor to bring about a balance of temperature between the steam and the water. While this action is taking place the steam bubbles rapidly ascend and expand. Until such a time as it reaches the surface it absorbs its last and final allowance of heat, and ascends into the steam space at a temperature very little below that of the water. And by careful test it has been found that during this process the bubble of steam has absorbed heat in proportion of approximately 965 B. T. U. per pound, while expanding to 1700 times its original volume under a pressure of 14.7 pounds per square inch. As the steam rises and fills the steam space, the pressure rises gradually above that of the atmosphere, therefore the temperature required to bring about the formation of the steam bubbles increase. As the boiling point is higher as the pressure increases, the ratio of expansion decreases, requiring less additional heat in proportion to the pressure per square inch, hence the economy in the generation of high pressure steam. Now steam during process of expansion absorbs heat from the surrounding water, exactly as the ammonia gas in refrigerating coils absorbs heat from the brine or other medium, as the case may be.

It is claimed by some that steam during formation does not fall below the temperature of the water, on the theory that if such should be the case the steam would instantly condense and return to its original form. It is undoubtedly true, to a certain extent, that some portions of the steam will condense and assume the form of water, but in so doing it occupies a smaller space, thereby giving up some of its heat to other adjacent particles. Some also claim that the whole process of formation and expansion takes place on the surface. Admitting this to be a fact, then the latent heat must be supplied through the water, as there is no other medium through which it can be supplied, as it is an assured fact that there can be no transfer of heat nor any other substance or element from one body or place to another unless there be a difference of pressure or condition favoring such transfer. Therefore heat cannot be transferred from the furnace through the water to the steam unless the temperature of the water is lower than that of the furnace, and the temperature of the steam lower than that of the water. There must be a difference of temperature, if ever so little.

Since it has been proven above that any body or particle of water would have to attain a temperature of at least 1177° F. to produce steam at atmospheric pressure, without the addition of the heat, it follows, that if a particle of water received their full allotment of heat while in contact with the heating surface of the boiler, the material of which the boiler is composed must attain a temperature slightly in excess of 1177° F., which, to say the least, would be productive of boiler explosions.

The foregoing article was not written with any intention of trying to correct any mathematical error or deficiency, but to make more plain a principle that seems to have been neglected by the majority of writers. While the whys and wherefores of latent heat may not affect a man's usefulness as an engineer, still it is a good thing to know and cannot in any way impair his usefulness. The above calculations are mostly approximate, but are sufficiently close for the purpose.

—o—

Boiler Explosion at Lansing, Mich.

A boiler in the plant of the Maud S. Windmill and Pump Co., located at Lansing, Mich., exploded at 6.25 o'clock on the morning of January 31st, and resulted in the death of Lucian Gilbert, the engineer. The bones of both legs below the knees were broken in several places and he was so severely scalded that death resulted some hours after the explosion.

The boiler room, which was a brick structure, located on the south side and near the west end of the main building, was completely demolished, and the boiler was thrown twenty feet in the air and thirty feet to the east by the force of the explosion, and was turned nearly around. Bricks were scattered about the premises and the smokestack was twisted and doubled like a pipestem. One of the three steel plates that covered the boiler was flattened out straight, and the flues were sprung, as were both ends of the boiler. The plate was forced completely from the boiler, the weakest part of the metal apparently being near where it was riveted to the boiler frame, except on the top, where the metal was torn apart as if it had been paper, leaving a ragged edge.

Several theories as to the cause of the explosion have been advanced, one being that there was not a sufficient amount of

water in the boiler, while other persons say that the boiler was not in good condition and had become weakened and defective from minerals in the water acting on the metal.

The engineer arrived at the factory about 6.15 A.M., and as was his custom asked the night watchman if everything was all right. Shortly after the watchman left, the boiler exploded, and when he returned to the boiler room found the engineer covered with *debris*. Several experts examined the boiler after the accident and it is said that it was undoubtedly due to the fact that there was no water in the boiler at the time of the explosion and that it was red hot when water was suddenly injected into it. The watchman, however, declares that the gauge showed the boiler to be three-quarters full of water and that unless the water gauge was defective or had become clogged up, the boiler could not have exploded because of lack of water. The boiler, it is said, was about fourteen years old and when overhauled last fall was found to be in fairly good condition. The boiler was not insured and therefore it had not been inspected by an expert.

This accident has given renewed impetus to the argument for State boiler inspection and the licensing of engineers in Michigan.

The Largest Single Leather Belt in the World to Drive a Tacoma Sawmill.

In the equipment of the Dempsey Lumber Company's new sawmill, at Tacoma, Washington, Corliss engines are used to belt-drive a full sawmill equipment of band saws and sawmill machinery generally, and not the least interesting feature of the new plant is the main belt which transmits the power from engines to the sawmill machinery proper.

This belt, made by the Chicago Belting Company, has the distinction of being the largest single leather belt in the world. It was made from pure oak-bark tanned leather; is eighty-four inches in width, three-ply in thickness, and weighs just 2300 pounds. The belt is 114 feet long, it took the centers of the hides of 225 steers to make it, and each piece of this leather was separately stretched before being placed in the belt.

In putting the belt together, no pegs, rivets or fastenings of any kind were used except cement of the best quality, and the plies were cemented together under a hydraulic pressure of 250 tons. As no hide will produce a single piece of leather wide enough to make a belt of this width, it was necessary to use two or three centers to make it. These pieces are cemented together, a two-inch longitudinal lap being used. This lap was made entirely by hand. As there was about seven hundred feet of this work, it required a considerable space of time. The finished belt has the appearance of a single piece. Sawmills are operated under widely varying loads, so that the service required of the driving belt is most severe. Any piece of leather, therefore, used for this purpose must bear the maximum strain of the sawmill, for this maximum is often reached.

The pulleys used have broad surfaces to give the necessary adhesion for delivering the required horse power. The Dempsey mill equipment is typical of this practice, and in addition combines every modern improvement which is known to sawmill and power plant design.

The mill building is 66 feet wide and about 500 feet long. The power plant will consist of eight 72-inch by 18-foot pressure boilers with Dutch oven settings connected to a concrete stack 100 inches in diameter and 120 feet high. A twin Reliance engine having cylinders 26 inches in diameter by a 36-inch stroke is installed, in addition to the unit of the same make which drives the electrical generating machinery for lighting purposes as well as for driving the planing mill, where each machine will be separately driven from individual induction motors.

84-Inch Belt.—The Largest in the World.—To be used for Saw Mill at Tacoma, Wash.

In the use of variable speed motors for the individual drive of machine tools, there are two points to be carefully considered:

(1) The size and weight of the motor is dependent to a great extent on the minimum speed at which the motor is required to develop its full-rated power; the slower the minimum speed the greater will be the size and weight for a given horse-power output.

(2) The maximum speed of the motor is dependent on the peripheral speed of the armature, commutator, pinion, or belt; or upon the ratio speed reduction between the driven shaft and the motor shaft. This limits the maximum speed to 1000 to 1600 R. P. M., depending on the output of the motor. The maximum speed being thus fixed by mechanical limitations, any increase in the range of speed variation must be obtained by decreasing the minimum speed and consequently increasing the size of motor for a given output, or decreasing the output for a given size. These mechanical limitations make it desirable to keep the speed range down to a reasonable amount.

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Future of Enginering.

While it may seem to all of us that the world has made considerable progress along engineering lines during the past twenty years, yet the average inventor whose horoscope widens the angle of his vision, assures us that we still are only a short way on the journey to scientific achievement.

This thought was brought to mind by the recent interview which was had with Mr. Edison on the day when he celebrated his sixtieth birthday. He said: "We are all busy in collecting data, we investigators, and maybe in five hundred years more we may begin to suspect something." This remark certainly seems to be justified when the achievements of recent years are considered, and whatever the labors of inventors and scientists have taught us, it shows that the merest beginning has been made and that vast fields of accomplishment still remain to be conquered.

When it is recalled that twenty-five years ago, the telephone was regarded as an interesting toy, that the trolley car was unheard of, that the steam engine was only a dwarf as compared to the sizes in which it is made to-day, that the X-ray, wireless telegraphy, airships, automobiles, steam-turbines are only, comparatively speaking, affairs of yesterday, the chances of future progress appear full of promise. Only six years of the new century have passed and yet the power plant as built to-day is entirely different from the plant of the last century. The change from the old system to the new, with its high tension alternating current distribution, has in reality only been most noticeable since the beginning of the century.

Only a dozen years have passed since Niagara Falls was first harnessed for the distribution of electrical energy, and since that time hydraulic plants have become very numerous throughout this country. The use of steam turbine dates from 1901, and there is now probably about 1,000,000 horse power being generated by that type of prime mover.

It has only been a short time since gas engines of any appreciable size have come into use for central station practice, but they are now a recognized factor in that class of service. Engines as large as 5,400 horse power are now being used by the California Gas and Electric Co., and many other smaller units are in successful operation. The suction gas plants are yet in their infancy, but they give every promise of becoming an important competitor to the steam plant. It is said that suction gas plants will work in the smallest sizes as economically as in the larger. They occupy little space and require but little attention.

Of the different methods of utilizing the gas engines which have sprung up, the application of this type of prime mover has been the most important in the iron industry, since the blast furnace as a potential source of energy not only serves to convert the raw material into pig iron, but also produces gas as a valuable by-product. This gas can be used for producing the power that is required in the power plant proper and besides leaves a considerable surplus available for other uses. The gas engine plant of the Lackawanna Steel Co., at Buffalo, uses a total of 32,000 horse power in blowing engines and 8,000 horse power in direct connected electric units.

With the improvements of the steam turbine, the gas turbine and the internal combusion engine, still to be attained, and the methods of utilizing the energy thus produced, to be increased, it is probably true that at no previous period of the world's history have so many minds been occupied with an

attempt to penetrate into the secrets of the laboratory of nature, so as to make their discoveries of importance to the engineering world and serviceable to mankind.

—o—

Removal of the Little Drops of Water in the Atmosphere.

At the present time in many industries there is a demand for apparatus by means of which either the moisture in the air must be removed or by means of which the air used will become saturated. One of the industries in which the removal of moisture has become quite important is in the iron industry, where the efficiency of the blast is greatly increased by condensing the moisture in the air by means of refrigeration. One of the important applications of using the air as a conveyor of moisture is in the cooling tower, about which most engineers are more or less familiar.

There are many other applications of the use of dry air, as well as utilizing it in a saturated condition, and the article entitled "Principles of Hygrometry," by Dr. Jos. H. Hart, found in another column of this issue, is very interesting, as it clears up very many cloudy ideas about the value of air for drying and cooling purposes.

In all cooling and drying devices, advantage is taken of the fact that an unsaturated vapor tends to become saturated when placed immediately in contact with a liquid of its own substance and tends to remain so, the advantage of the presence of air from a mechanical point of view being simply to furnish a convenient carrier for the water vapor by means of which it can be conveniently held and moved. As Mr. Hart clearly points out, the efficiency of a cooling tower depends absolutely on the quantity of saturated vapor which can be brought into immediate contact with the water, and this depends within certain limitations upon the quantity of air which can be brought under the same conditions and upon the surface of the water to be cooled.

A great mistake is often made, says Mr. Hart, in cooling-tower practice by using fans to drive the air rapidly through the entire length of the tower. The air, being merely a conveyor of the unsaturated water, becomes saturated almost immediately upon contact with the first layer of water in the tower and the further progress of this saturated vapor and the air which drives it, is a distinct economic loss in the operation of the plant. For this reason, Dr. Hart says, atmospheric cooling towers are much superior, from an efficiency point of view, to those operated by fans.

Of the other applications of the use of dry air, in which it would be advisable to remove the moisture from the atmosphere, may be mentioned compressed air, because the efficiency of the compressor would be greatly enhanced if no moisture were present in the compressor cylinders. If, also, the moisture in the air could be removed before the air were used in cooling towers, it can easily be seen how much more efficient this piece of apparatus would become.

Along theoretical lines, the principles of hygrometry have been more or less thoroughly understood for a long time, but practice has been sadly left in rear in the application of these principles. This has been probably due to the fact that engineers have thought that the game was not worth the candle, but in these days of intense efficiencies, even the drops of moisture in the atmosphere are giving annoyance and they must make way before the march of progress.

—o—

Lap Seam Boilers.

In commenting upon the Lynn explosion (and also upon the previous explosion at Brockton), a number of persons, including some well-known engineers, have suggested that the use of the lap seam be absolutely prohibited by law, the butt joint, which apparently is not liable to similar cracks, being required in its place. This appears to us to be a rather drastic proposition. We should like to see the lap seam discarded altogether for boilers carrying considerable pressures; but we are aware, at the same time, that the lap joint is regarded by many as entirely satisfactory when it is well designed and well constructed. At all events, designers of admitted ability continue to make use of it, as they would not do if they were satisfied that it was markedly dangerous. It is probable that 80 per cent. of all the boilers now in use in the United States have lap joints; and the proposition to make the further use of these boilers illegal strikes us as calling for the most serious consideration before acceptance. Certainly there never has been (so far as we are aware) any municipality or State or government, nor any bureau of steam engineering, which has yet made any permanent, wholesale and unqualified condemnation of the lap joint. In view of these facts, it is certainly reasonable to suggest that the matter be most carefully considered before manufacturers and boiler owners generally are put to the enormous expense and inconvenience that would be involved in prohibiting, at once, the use of lap-joint boilers. We are not here pleading for the continued use of the lap joint, but only for reasonableness in any legal enactments that may be contemplated by the legislators of the country.—*The Locomotive.*

—o—

When burning coal for the purpose of generating power, there are a number of items to be considered besides the price and thermal capacity of the coal. In large power plants the item of fuel cost is composed, besides the price for the coal, of the expense of handling it between the car and the ash-pile and the money involved in storing a sufficient quantity to insure continuous operation in cases of emergency, or when the supply service is interrupted. If the price of the coal is reduced per ton, the amount of capital tied up will be diminished for a given number of tons stored, but on the other hand, tests have shown that the fuel consumption of the steam plant is increased comparatively much more rapidly with the poorer grades of coal.

—o—

Armature cores of generators and motors should be built of sheet steel punchings insulated from each other to reduce the core loss and subsequent heating. In building up the core the laminations should be separated at intervals so as to form ventilating ducts. In punching the armature disks, openings should be made in the disks, so that when the parts are assembled, ventilating passages are formed parallel to the shaft and connecting with the radial ducts. There is thus a free passage for circulation of air through the core, and all parts of the core and windings are thoroughly ventilated.

LETTERS FROM ENGINEERS

IN ORDER to make this department of THE PRACTICAL ENGINEER as interesting as possible, a moderate rate will be paid by us for all contributions published under this heading. However, we do not assume responsibility for the ideas or opinions expressed. None need hesitate to contribute because of inability to draw or write well. We will redraw or revise whenever necessary—it is the idea we want. New ways of doing old things, criticisms of accepted theories, and general engine-room experiences are especially solicited.

The Proper Reason for the Addition of the Extra Stuffing Box on a Deane Pump.

EDITOR THE PRACTICAL ENGINEER:

I note on page 26 of the February issue a letter, signed "M. H. H.," in reference to stuffing boxes on the valve rod of a Deane pump. The writer of that communication has an entirely wrong idea as to the object of this extra stuffing box, which the Deane people have put on the outside end of the valve chest. Perhaps you will wish to correct his theory, and give the proper reason for the addition of this extra stuffing box.

When these pumps were first put on the market, the steam pressures were very much lower than at present, and the trouble which has been experienced later was not evident at that time. Of late years the steam pressures have been increasing, and when these single pumps are working under a high steam pressure it sometimes happens that the auxiliary valve is thrown before the tappets on the rod are struck by the tappet block. This, of course, short-strokes and sometimes stops the pump.

Any engineer who has had this trouble with his machine, and has noticed it carefully, would observe that it has always occurred on the inboard stroke of the valve rod. This is due to the steam pressure acting on the unbalanced area of the valve rod. In other words, the auxiliary valve was thrown before the proper time by means of the steam pressure acting on the end of the rod. By the addition of the stuffing box on the outer end of the chest the unbalanced area was done away with, and the difficulty overcome without putting extra friction on the rod.

The stuffing boxes can be made just tight enough to hold the steam, and there is no need of tightening them up to put friction on the rod, as the steam pressure has no unbalanced area on which it can act, and the rod therefore will not move until the tappets come into play at the proper time.

Holyoke, Mass. H. M. C.

Two Rings Will Cure Trouble with Corliss Valve Stem Packing. Examination should Reveal C. A. B.'s Trouble.

EDITOR THE PRACTICAL ENGINEER:

I note C. E. A.'s letter on page 30, of the February issue of THE PRACTICAL ENGINEER and the trouble he is having with his valve stems. I would suggest that he try *two* packing rings on each stem instead of one; that is, the thickness of the two rings should be equal to the thickness of the single original ring. This, I think, will tend to reduce the trouble if not wholly to remove it.

There appears to be something wrong with the governor or its attachments of C. A. B.'s engine, as complained of in letter on page 30, same issue. A careful examination should locate the trouble. Perhaps some of the connections bind too tightly at certain places and an examination of all should be made. Perhaps the oil in the dash-pot is too thick or too thin. Make a trial with different kinds of oil and note results. It may be that the levers, rods, arms, etc., which connect to the governor and valves are not balanced and at certain positions the overbalancing effects are felt more than at other positions. Perhaps the steel tails of the valve hooks, and the cams against which they work, in order to disengage the valve from the hook, are so worn that the valves are not promptly released. Any or all of these things may be the cause of C. A. B.'s trouble. It is fair to assume that the engine was all right at some time and that the present trouble has grown out of something that has altered, or something that has been done before the trouble began.

Examine the valve gear along the lines suggested and perhaps something may be discovered.

CHAS. J. MASON.

The Plunger Elevator.

EDITOR THE PRACTICAL ENGINEER:

As I have never seen anything pertaining to the care and management of the hydraulic plunger elevator in any engineering magazine, I thought, perhaps, there may be more engineers in the same fix as I was on taking charge of my first plant of its kind, and what little I have learned is at the service of my brother-engineers.

The plunger elevator is extremely simple, but it is a machine, nevertheless, and as such, it requires care, especially if it is a fast passenger elevator. The greatest danger of a plunger elevator is its apparent safety, but it is no safer, and perhaps more dangerous, than the other kinds, in the hands of a careless or ignorant man.

To have a smooth running and safe plunger elevator, constant care must be exercised that valves, controllers, safeties and plunger are in good working order; the plunger packing needs constant care, as only a slight leak causes a great nuisance, besides the loss of water, which is a considerable item when you have to pay for it. I find that by greasing once a day, using a good grade of medium light grease made of oil—a grease that has much wax is not suitable—that the packing will keep soft and last well. I grease the plungers by rubbing over every part of them with the hands, starting with the car at the top of the well. If the packing should show a leak, I do not rip the old packing out at once but I put a thin layer of soft-braided flax, that is filled with grease and graphite, on top of the old packing and set the gland down on it; as a rule that will keep tight and run easy for some time.

Pilot valves and controllers are packed with leather cups; if the cylinders are in good order, then a good leather cup will last a good while. I take them out once in a while and grease them well with a mixture of grease and graphite. If the car should creep I can, if the cup packings are good, stop it by moving the valve lever up or down on the operating rope. I prefer to have the cars slide and let the operator judge the distance it will slide to the floor landing, because there is not so much strain on the car or gearing, and it is more pleasant for the passengers.

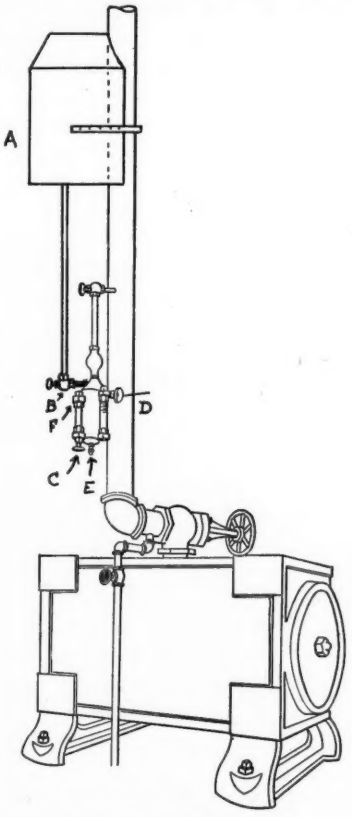
Never let a car come down hard on the bumpers; by regulating the top and bottom stops, the car will come to top and bottom landing gradually if the operator should be careless, although an operator should never depend on the stops.

Dorchester, Mass. C. A. H.

Method of Filling Lubricator.

EDITOR THE PRACTICAL ENGINEER:

The accompanying diagram shows how I connected up a lubricator to an oil tank in order to do away with the cylinder oil can and at the same time have a plentiful supply of hot oil under a slight pressure all the time. It is a self-filler and enables you to fill the lubricator in an easy manner without spilling a drop. A is a tank holding about two gallons. It is made of galvanized iron or very heavy tin plate, and is shaped as shown to fit partly around the steam pipe, being held in place by a strap iron clamp. There is a hole in the top of can for filling it. The tank is connected to the lubricator opening, which is used for filling by means of ⅜-inch piping with an angle valve placed at B, as shown. This valve must remain closed at all times except when filling the lubricator. For this



Oil Tank for Lubricator

reason I use a lock, shield and key valve, so that no one can open it carelessly.

In order to fill the lubricator, drain it in the usual way by closing valves C and D and opening drain cock and air cock F. When all the water is out close drain cock E and open angle valve B, when oil will run from the tank A, which has been previously filled, into the lubricator. When the oil shows out of the air cock F, the lubricator is full; then close air cock F and angle valve B, open valve D and the lubricator is ready to start feeding again by adjusting valve C.

To make the pipe connection at the bottom of the tank, a couple of lock nuts with a gasket can be used. The method I used was to solder a ⅜-inch brass nipple into the bottom of the tank. SCOTT.

Cambridge, O.

Some Interesting Facts About Cut-off, Steam Distribution, and Receiver Pressures of Compound Condensing Engines.

EDITOR THE PRACTICAL ENGINEER:

I notice R. D.'s article in the February issue, and I am glad to enter into a friendly argument on this question. As it is a theoretical question, it should, I think, be handled as such and practice left out.

In the theoretical engine, there are no losses through radiation and condensing, therefore the receiver pressure, or the initial pressure in the low pressure cylinder, should be the same as the terminal pressure in the high pressure cylinder. If practice is brought into play and the receiver pressure dropped, the entire result is changed. Furthermore, if the pressure is changed, the condition resulting from such a change should also be taken into account and not the reduced receiver pressure alone.

The receiver pressure can only be dropped by lengthening the point of cut-off in the low pressure cylinder; this, causing a drop in receiver pressure, produces also a drop of back pressure on the high pressure piston, causing the governor to ride in a higher plane, with the result that the cut-off is made earlier and not one-quarter as taken. The low pressure cut-off will also be shortened by the governor rising, which will cause a change in receiver pressure again, besides the change produced by hand adjustment. This also causes a change in terminal pressure and we are working under an entire new set of conditions. If we try to figure this question on this basis we will find ourselves in a nice little tangle. To use simply the drop in receiver pressure and not the resulting conditions, is not a square deal.

In regard to the 65% efficiency, I take it that RD allows 35% for loss due to condensation and radiation which do not count in the theoretical engine. Even in practice I think this is too high for a cross-compound condensing engine.

In the plant where I am employed we have a 1500-horse power cross-compound condensing Corliss engine installed in 1895. The cylinder barrels and crank heads are steam-jacketed. The actual mean effective pressure, as taken by indicator cards and figured by the planimeter, is only two pounds less than the theoretical mean effective pressure, as figured from the formula. This is only 3%, and while in an engine without the steam jacket the loss would run higher, it would not reach 35%, I am sure.

In regard to the equal distribution of the load between the cylinders, I do not think that the formulæ amount to much except in purely theoretical work, and cannot be used unless the high-pressure terminal pressure is equal to the low-pressure initial pressure or receiver pressure. As to the proper receiver pressure, this question has been discussed in this paper.

The highest plane that the governor will ride in and still carry the load and maintain the speed is the most economical way to run an engine. Applying this to a compound engine,

the receiver pressure that will allow the governor to ride in the highest plane and still carry the load and maintain the speed is the most economical receiver pressure, regardless of the equality of load between the cylinders, because it is obvious that the higher the governor rides the less steam is used.

As an illustration, we also have a 1000-horse power Harris Corliss cross-compound condensing engine, and it was found by trial that at 7 pounds receiver gauge pressure, the governor rode in a higher plane than at any other pressure, although the low pressure cylinder is doing about 100-horse power less than the high pressure cylinder.

New Bedford, Mass. F. W. C.

Simple Rule for Finding Size of Cylinders for 2000 H. P. Engine.

EDITOR THE PRACTICAL ENGINEER:

The following is a method for finding the diameters of the cylinders of a 2000 horse power engine without using the complicated formula which is laid down in text books and which uses hyperbolic logarithms:

Assuming a boiler pressure of 145 pounds or 160 pounds absolute, we will also assume that the engine will give good economy with 16 expansions and that each cylinder should do 1000 horse power of work.

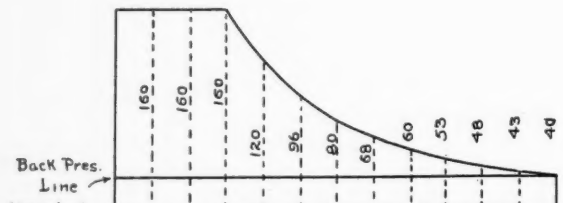


Fig. 1

As we do not remember that hyperbolic log. of 16 or of 4, we proceed as follows: Draw an indicator card and divide it into twelve equal spaces. As there should be four expansions in the high pressure cylinder the cut-off takes place at ¼-stroke; then by adding the pressure found in those twelve spaces, and dividing by the number, the mean pressure is obtained. The height of the vertical lines which represent pressures is shown in Fig. 1. Since the cut-off takes place at ¼-stroke, the height of the first three lines represent 160 pounds absolute; the fourth line will be ¾ of the initial pressure; the fifth line will be 3/5; the sixth line will be 3/6; the seventh line will be 3/7; the eighth line will be ⅜, and so on, the twefth line being 3/12 of the initial pressure in height. The twelve heights are then as follows: $160 + 160 + 160 + 120 + 96 + 80 + 68.57 + 60 + 53.33 + 48 + 43.63 + 40 = 1089.53$, giving the sum of the heights and dividing by their number gives $1089.53 \div 12 = 90.79$. As the back pressure on the piston is 40 pounds, the mean pressure equals $90.79 - 40 = 50.79$ pounds. This will be found to closely coincide with the theoretical mean effective pressure figured from the rule found in most text-books, which states that the actual initial pressure multiplied by one plus the hyperbolic logarithm of the number of expansion divided by the ratio of expansion minus the back pressure.

According to this rule we would get a mean pressure of 90.45, and subtracting 40 pounds, the back pressure, the mean effective pressure becomes 50.45, or only 0.34 of a pound difference.

The diameter can now be found from the well-known horse power formula assuming a piston speed of 800 feet per minute, the formula becomes

$$A = \frac{33000 \times 1000}{50.79 \times 800} = 812.16$$

from which by dividing by .7854 and extracting the square root, the diameter can be obtained. In this case the diameter is found to be about 32 inches. By increasing the piston speed the diameter could be reduced and by decreasing the piston speed the diameter could be increased, the mean effective pressure remaining the same.

In the case of the low pressure cylinder, we have 40 pounds initial pressure to start off with, and following the same rule as was used for the high pressure card, the sum of the pressures becomes $40 + 40 + 40 + 30 + 24 + 20 + 17 + 15 + 13.33 + 12 + 10.92 + 10 = 272.38$, and dividing by 12 gives 22.69 as the mean pressure, and subtracting the back pressure 2, the mean effective pressure becomes 20.69 pounds. According to the same rule above referred to, the value according to the text books would be 20.94, or only 0.25 difference.

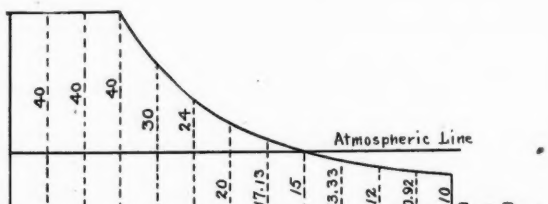


Fig. 2

Having the mean effective pressure, the formula for the area of the low pressure cylinder becomes

$$A = \frac{33000 \times 1000}{20.69 \times 800} = 1993.7$$

from which the area will be found to be about 50 inches. According to these dimensions, the size engine you would get from the builder would probably be a 32 x 50 x 48.

All the work in the above example can be done with a pencil and a common 2-foot rule.

Fall River, Mass. M. H. H.

Catch Examination Questions.

EDITOR THE PRACTICAL ENGINEER:

In answer to question No. 3 of F. S. H., of Mt. Tom, Mass., on page 26 of the January number, I would be liable to tell the examiner that such a condition of things would not be possible. Any steam pump that would act in such a manner would indeed be a wonder; because if it is the regular style of steam pump used for boiler feeding purposes, it will be sure to race when it stopped throwing water, and therefore it would not apparently be working all right from the outside. The pump would also throw more water working against atmospheric pressure than against 80 pounds. I think it is a

catch question to find out just what practical experience the applicant has had.

This is something like a question that was asked me by the examiner when he said, "Suppose you were pumping water into a boiler with a steam pump that was all right, but the water level was not rising in the boiler, what would you think was the trouble?" I told him that the gauge glass might be stopped up or the blow-off valve might be leaking. Then he said, "Suppose they are all right, what would you do?" I answered him that if the pump and pipes were all right, the water was sure to rise in the boiler, because it could not get anywhere else. Then he said, "Suppose there was a hole in your boiler?" I replied that if there was I would very soon know it.

This also puts me in mind of a question that was asked a young man, which was as follows: "What would you do if the manhole cover fell in with a working pressure of 80 pounds?" He replied that he would immediately strip off his clothes and dive in after it because a manhole cover that would be guilty of such a trick would be worth looking at.

Fall River, Mass. J. R.

Tapered Keys.

EDITOR THE PRACTICAL ENGINEER:

Where tapered keys are used for adjusting brasses, it is often desirable to know how much the brasses will be closed in on the pin by a given movement of the key, or how much to back out a key that has been driven home until the brasses nip the pin, the clearance between the brasses and the pin necessary for satisfactory running having been decided on.

To find the amount the brass has been moved, multiply the taper by the distance the key is driven and divide the product by twelve. To find how far to back out a key, multiply the amount the brass is to be moved back by twelve and divide by the taper or, let

t = taper in inches per foot
d = distance key is driven in inches
x = amount brass is moved in inches,

then, $x = \frac{td}{12}$ and $d = \frac{12x}{t}$

The taper per foot can be ascertained by subtracting the small diameter from the large diameter, multiply the remainder by twelve and divide the product by the length of the key.

Decatur, Ill. W. F. B.

Ads and Handbook Question.

EDITOR THE PRACTICAL ENGINEER:

Anent the discussion as to the educational value of advertisements and catalogs, the number of readers who have already called to account the correspondent signing himself "Golden West" shows that many engineers do appreciate these branches of our technical literature.

Aside from the acknowledged fact that only by a study of these can a man keep up with the new and useful appliances pertaining to his business that are constantly being placed on the market, there is certain information often to be desired, that can only be found in these branches. To specify one case and to still place myself in a position where it cannot be said that I am personally "interested," I will cite the ads of the Cincinnati Milling Machine Company which have been illustrating and explaining for some time in a well-known paper for machinists, the best and most economical methods of doing milling as developed by practice in their own shops, giving details unobtainable elsewhere except by personal experiment. Our friend from the "Golden West" would look a long time in handbooks for this kind of knowledge. I have frequently written manufacturers for their catalogs and explained in my letter that I was not in the market at that time for their goods, but that I desired to keep in touch with certain improvements they were bringing forth, or because their catalog contained some information I desired, etc., and I cannot recall an instance where I did not receive not only the catalog requested, but also a courteous letter inviting me to ask for further information at any time.

For a man in ordinary circumstances, the handbook question has another viewpoint. Take the electrical business for the past ten years, and how many handbooks would have had to be purchased in that time to keep a man within hearing distance of the front rank? However, the publicity department of the General Electric Company and others in that line send out regular bulletins in a convenient form for filing, that furnish much information to an interested student. Such advertising literature, when taken in connection with one's trade papers and one or two handbooks, will give all the knowledge the average man has time to absorb and apply.

In regard to sarcastic letters, I think if the editor of THE PRACTICAL ENGINEER would request that all letters containing comments on other engineers' contributions be printed over the real name and address of the writer, that such correspondents would in many cases be a little more thoughtful of what they said and how they said it.

East Greenwich, R. I. L. L. ARNOLD.

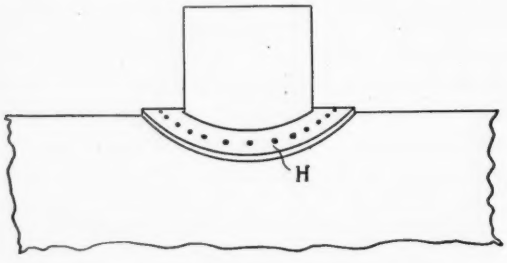
Public May not Care, but Employers Do.

EDITOR THE PRACTICAL ENGINEER:

I have read the article by P. E. in the January issue headed "Public Does Not Care," but do not agree with him, especially as regards the engineer not having any say about the design and constructing of a plant. On the ninth day of July, 1868, I started in as a boy to learn to be an operating engineer and I took up my duties with one idea in mind, "I will always do my duty in the minutest detail, so that they will miss me when I am gone." To-day finds me the chief engineer of the plant in which, in 1869, I started in as a lumper.

From that time, thirty-seven years ago, when I asked my employer for a new broom to keep the engine room clean, until now, I have never been refused anything I asked for. Every appliance in our 700-horse power plant came upon my suggestion. Employers do care about their plant and they want a man who cares, too. I have never thought it fair to be all the time berating my employer and thinking that I am an angel. P. E. emphasizes his argument by speaking of the case of Harney & Co. at Lynn, Mass., and in reference to the explosion he quotes the engineer as saying that there was a crack in the plate of the boiler which exploded and that the owners would not take any notice. Now I don't believe Engineer Dunning did say what the papers quoted him as saying, but if he did say that the crack would contribute anything toward causing the boiler to explode, I do not wonder that the owners cared little for his judgment.

Now if I am correctly informed, the crack spoken of was not in the plate at all, but it was a rivet hole cracked out in the casting which is put on all boilers for reinforcing the plate where the hole was cut in the plate for the manhole casting.



Crack at H will not cause Explosion

As I am informed by one of the inspectors, the crack was somewhere in the riveting of the casting; perhaps not just the position shown at H, but practically the same. Now any of us who have judgment born of practical experience knows full well that a crack of this kind could never lead to a boiler explosion. S. T.

Watertown, Mass.

Mr. Mason Gives Some Good, Sound Advice About the Qualification of an Engineer.

EDITOR THE PRACTICAL ENGINEER:

The writer of the letter, which appeared in the January issue of THE PRACTICAL ENGINEER, who signed himself "Golden West," will have an opportunity of "seeing himself as others see him," judging from the tone of the two letters which appear in the February issue, relative to the matter. Such expressions of opinions as given vent by Golden West will never win friends for him, but on the contrary will tend to undervalue a perhaps otherwise estimable person. He should remember the title of one of Charles Reade's books, "Put Yourself in his Place," and then acting upon that advice perhaps he could have been charitable toward the person whom he tried to belittle. He appears to have constituted himself a judge, jury and counsel in the case and hands down a decision which he evidently thinks admits of no dissent.

As a general rule, educated men, well read men, sensible men, never belittle nor do anything to make another feel small and of little consequence. Lauding it over a less fortunate brother is, to say the least, mean and unworthy of a man.

Perhaps the following lines—the origin of which I have forgotten—will convey to Golden West something he has never before thought of; and if he has a well trained mind he will find food for thought that possibly may do him lasting good. "By the grace of God, forbid that we should be overbold to lay rough hands on any man's opinion. For opinions are certes—venerable properties; and those which show the most decrepitude should have the gentlest handling."

Now aside from all this I would like to say, as many others have said, that a mechanical training such as is obtained in machine works, engine shops and other engineering establishments enhances the value of an engineer. But it must not be thought that all shop men turn out to be engineers. To become a skilled mechanic is one thing; to become a real engineer is another. The first requires years of training and ordinary ability; the second requires in addition talent and extraordinary ability. Some first-class mechanics who have been through the various divisions of their trade, capable men in the shop and able to construct and erect machinery, have proved dismal failures in the operating and maintaining of such machinery for any length of time. They were unable to see into things and to understand the underlying principle of things and to conceive of things as the engineer frequently has to do. It is quite possible for a man to become a first-class engineer without ever having served a day in the machine shop. The knowing how to handle mechanical tools, to be able to do a "good job" is not at all the *most* essential part of an engineer's qualifications.

I have been shopmates and shipmates with all kinds of mechanics and engineers and have carefully noted the difference between the various classes of men with whom I came in contact, and I have come to the conclusion that some men will never become engineers no matter what course they would pursue, simply because their talents do not lie in that direction. On the other hand, the man who has engineering talent will, if he chooses, "get there" and not necessarily via the machine shop route.

If Golden West is the man he would have the readers of THE PRACTICAL ENGINEER think he is, he will not hesitate to offer an apology to the men whom he has so discourteously treated. Let him remember that "He that controlleth himself is greater than he that taketh a city."

Scranton, Pa. CHAS. J. MASON.

Thinks Men With Special Licenses Good and Practical.

EDITOR THE PRACTICAL ENGINEER:

In reply to C. T. P., in the February issue, I would say, don't despise a man for doing the best he can, as some of the special men have not even had the advantage of a grammar school education, but are good, practical engineers just the same, and a gold seal on their license would not make a particle of difference in their salary. I will state two cases in proof of what I say.

There is a street railway power house here and the plant is about 2400-horse power capacity, the engines running compound condensing and the station equipped with the latest wrinkles, steam loop and all. The engineer in charge is a special license man, and he has been with the plant since it developed from a 200-horse power plant. He can't figure, he can't even write or read, but he keeps the juice flowing in the trolley wire every hour of the day and 365 days in the year, and he has not much time to learn except from practical experience. Engineers who were made in this plant and who are carrying high grade licenses and are proud of it, but they owe the gold seal to this chief and they are not ashamed to say so.

Now, on the other hand, we have a plant here of 250-horse power capacity running condensing with cross-compound engine, and the man in charge has a first-class license. He took the place of a special license man and for the first month he was there the machinist started and stopped the engine because the first-class man did not know enough, and the superintendent at the mill knew it, even if the inspector that gave him the first-class license did not.

Here is a question I failed on when applying for a second-class license, the inspector who asked the question being the present Deputy Chief: "If you were hired to take charge of

a 150-horse power Corliss engine and two 100-horse power boilers, the plant having been shut down and they did not want any power of steam on the boilers for three weeks, what would you do and could you tell at what speed your engine would run?" Now can C. T. P. answer this? I am oiling on a Knowlson & Kelly cross-compound condensing engine, 500-horse power; when the load goes off, the receiver pressure goes up, and when the load goes on, the receiver pressure goes down. Why is this?

Adams, Mass. T. S.

Education Costs Nothing to Carry Around with You.

EDITOR THE PRACTICAL ENGINEER:

Just a few words in reply to the criticism made by Golden West in the January issue. I am sure Mr. Scott, in the November issue, made a plain and practical understanding of the benefits to be derived from ads. and catalogues, and we should all be more pleased than otherwise with the statements. I have received, and many firemen I have had under me have received, a great deal of useful information out of ads. and catalogues, which has helped them in their climb to the position of engineer. I also agree with Mr. Scott that there are only a few engineers who can make up an order for supplies, pipe fittings, etc., unless they have at some time studied catalogues.

It is the duty of every engineer to keep abreast of the times, and one of the best ways to do it is to keep in close touch with the trade literature, as about all the new ideas and new apparatus will be found first in ads. and catalogues.

There seems to be lots of ideas in regard to what should be the education of an engineer. I do not agree with Golden West that a man should have four to six years' shop experience before he should be granted a stationary or marine license. We must not forget that some of our smartest engineers were lacking in shop practice and education. As I look at it, it is not so much a question of education as of ability. Education is a great help, costs nothing to carry around with you, and very often stands you in good stead; so let us get all we can of it.

If Golden West will read M. L. S.'s article in the November issue he will see that instead of him being an Eastern man, he

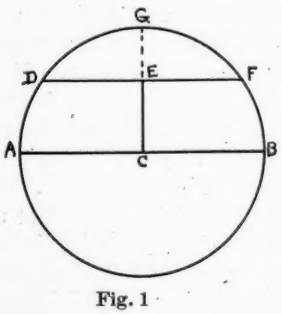


Fig. 1

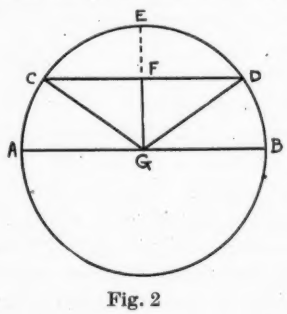


Fig. 2

is a brother knight of the throttle in his own city. In reference to the tank problem, I would like to give a few hints which may be useful. As the tank in question has already been figured up twice, I will only give some of the formulas and explain them briefly.

In Fig. 1, let the diameter AB be represented by D and the chord DF by C and the distance CE by A. Since GE is known CE may be found by subtracting GE from ½ of the diameter. Having AB and CE known, the first step is to find the length of the chord DF. The formula for finding the length of the cord is $C = \sqrt{D^2 - 4A^2}$, or the chord is equal to the square root of diameter squared minus four times the distance CE squared.

Another method for finding the chord is shown in Fig. 2, in which AB = diameter, CD = chord, EF = height of segment. Draw GC and GD as radii of the circle; then two right triangles are formed in which the radius of the circle, one-half of the chord and the required distance GF are the three sides. The formula for finding the one side when the hypothenuse and other side of a right angle triangle are given is to square the hypothenuse, subtract the square of the other side and extract the square root. Or, since GF and GD are known, $FD = \sqrt{GD^2 - GF^2}$, which equals one-half the chord, and multiplying by two gives the length of the chord.

Now, taking the area of segment, the formula for the area is

$$A = \frac{4h^2}{3} \times \sqrt{\frac{D}{h}} - .608$$

in which A = area of segment, H = height of segment and D = diameter of circle. There is also another rule which Golden West used, which is as follows:

$$A = \frac{H^3}{2C} + \frac{2}{3}CH$$

in which A = area of segment, H = height of segment and C = chord. Whichever is the simpler formula, the reader can decide.

I would say to Golden West in conclusion that when giving information it would be a wise policy to begin by building up the foundation and setting the engine thereon, rather than setting the engine, and then building the foundation.

Boston, Mass. E. R. S.

The Obstreperous Crank-Pin. Overloaded Engine the Cause.

EDITOR THE PRACTICAL ENGINEER:

Upon taking charge of a certain plant I found that everything in the place was in practically first-class condition except one engine, which was a 22" x 42" Corliss, running at 80 revolutions per minute. The crank-pin was loose in the crank-disc and was pounding very badly. The engine had to run night and day, from Sunday night until the next Sunday morning. On the following Sunday the crank-pin was taken out and refitted, the hole in the disc trued up, and the pin ground to what seemed to be a perfect fit, the pin shrunk in and the engine started about midnight Sunday. By Tuesday the pin had become loose again and it began to pound as bad as ever. At noon Tuesday, when the load was considerably lighter than at any other time, the load was shifted to the other engines and the engine in question was shut down long enough to lengthen the wrist-plate connections to the exhaust valves, giving them considerable more compression.

Upon starting up again the engine did not pound as before, therefore we reached the conclusion that lack of compression had been the cause of all the trouble. However, by the next Sunday the crank-pin had become so loose that it would turn in the disc, throwing the centrifugal oiler out of position, which, after a little practice, we could remedy without shutting

down. The engine was kept in operation until Sunday morning, when the operation of refitting the crank-pin was gone through again and new hub-bolts were put in the fly-wheel, as the fly-wheel showed some signs of working on the shaft. This time the engine was started about 3 o'clock Monday morning.

On Friday we found that the crank-pin was working loose again, and as the crank-pin had been refitted until it would stand no more, we had a new crank-pin made of nickel-steel, and instead of making the pin tapered, it was made straight.

On Sunday morning we clamped a boring apparatus on the disc and bored the tapered hole straight, after which the pin which was made a shrinking fit was put in with a ram made of a piece of six-inch shaft, ten feet long, swung from a truss 30 feet overhead. The fly-wheel bolts were also taken out, heated to a cherry red for about ten inches of their length, when they were again pulled up and allowed to cool. The engine was started at 3 o'clock Monday morning, and the crank-pin was still tight, one and one-half years later, when I left. However, during this time, the hub-bolts in the fly-wheel had to be replaced three times and they needed replacing wnen 1 left.

After the crank-pin had been finally fixed I began to investigate the history of the engine and found that it had been built about twenty years before with an original cylinder diameter of 20 inches and to be used with a maximum boiler pressure of 90 pounds per square inch, while we carried 130 pounds on the boilers. As the company a few years previous had needed more power, the 20-inch cylinder had been replaced with a 22-inch cylinder, new boilers had been installed and the pressure raised to 130 pounds. It is evident that this engine, which was originally designed for approximately 250-horse power, was doing over 450-horse power at ¼ cut-off. Of course the regular kicks came in from headquarters in regard to keeping this engine up.

There are numerous cases where practically the same conditions exist and many of the readers have no doubt experienced the same difficulties; and it is invariably the case that where such conditions do exist, the employer will expect the repair bill and oil bill to be just as low as in some nearby plant, where the machinery is modern, well-proportioned and not overloaded.

St. Louis, Mo. E. D. W.

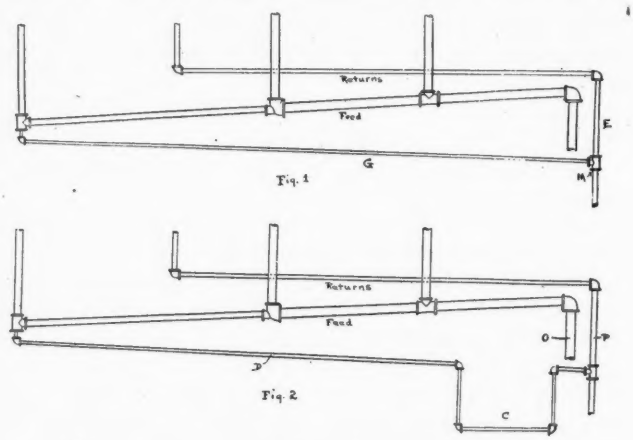
Radiator Drip Connections.

EDITOR THE PRACTICAL ENGINEER:

I have read W. H. Wakeman's answer in the February number to my letter in the January number and I still maintain that I am right, as a bleeder connected as shown by Mr. Wakeman in the December number will not give satisfaction in the majority of cases. That this arrangement is giving satisfaction in his own case is no criterion to go by, as there may be certain conditions existing of which I am ignorant, which will cause this arrangement to be a success in his plant. I am not talking from theory, either; as fifteen years of my life was spent on both sides of the line as a practical steam-fitter, and during all that time I do not remember seeing the drips connected as shown in Fig. 1, which is, according to Mr. Wakeman's plan, E being the return and G the drip, or bleeder, connected to the return as shown.

It stands to reason that the steam will follow along the drip and up the return at M into the radiators, thus preventing a perfectly free circulation. When a dry return is used there is generally a pocket formed on the drip as at C in Fig. 2. This fills with water and allows only the water of condensation from the steam main O to enter the return pipe P.

In using a wet return the drips should be connected as shown by me in the January number if a perfect working system is required. Mr. Wakeman says it will not work, but I assure him he is wrong, as I have fitted up dozens of houses, using wet returns, and in every case the drips are connected as shown. Be it understood that I am writing under the idea that it is the two-pipe, low-pressure, gravity return system of heating we are dealing with, irrespective as to whether the returns go direct back to the heater or receiving tank.



Radiator Drip Connections

Toronto, Can. SCOTTY.

Golden West Swings His Axe Again.

EDITOR THE PRACTICAL ENGINEER:

In the February issue of THE PRACTICAL ENGINEER I see that I am "bombastic," that "I ought to know better than to express myself as I do," that "I have shown myself to be very inconsiderate and sarcastic," also that my own information and consumption of oil per horse power was probably obtained from "some book or catalogue," an error was pointed out in the method given by me for finding the area of segments: all this, simply because I expressed my opinion on the method used by an engineer to obtain a first-class Ohio license. Now truly, Mr. Editor, I think you are partly to blame for the amount of criticism and advice that has been heaped on my poor head, by using that "blue pencil" of yours so freely on my original letter on the Education of Engineers, but then perhaps you actually saved me from complete destruction altogether. If my memory serves me rightly, I think in my original letter I partly expressed myself thus: "I have had many an uncomfortable hour myself on account of licensed men (so called engineers), but I sincerely hope it will never be my misfortune to entrust both life and property to a man who obtained a first-class license by the study of ads and catalogues."

Possibly I have too high an opinion of what amount of theoretical knowledge a first-class engineer should have, or I expect the employers to get too much out of one man, but I am still of the opinion that any first-class license which is granted on the limited and superficial theoretical knowledge which can be obtained from the best of ads and catalogues is

not a guarantee that the possessor of such is a first-class engineer; further, I consider that such examinations should be conducted by the Federal authorities, which would eliminate the possibilities of political "pull" which some of your correspondents insinuate is brought to bear on examinations in some of our cities.

J. T. asks, "Where did Golden West get all his supposed superior knowledge he is so willing to parade?" I will answer J. T. that the little knowledge I have I had to work hard for, and study when probably J. T. was in bed and asleep; as somehow I always did have the idea that to become an engineer, a man had to know just a little bit more than an oiler or fireman, and further when I came across anything that I could not understand, I hunted around until I could find someone who could explain it to me, even if I had to go to the head of the house. My information on the consumption of oil per horse power was not obtained from some book or catalogue, but came first hand by my being on the spot and seeing such tests made at regular intervals.

In reply to J. M., who resents the manner in which I give Mr. Scott the information regarding authors, I would remind him that Mr. Scott distinctly states, "None of my text-books explain how steam gauges work;" further on, "We go home that night and look through all our books for which we paid from one to four dollars and fifty cents per volume," and still Mr. Scott didn't find the desired information, so I simply judged Mr. Scott from my own disposition. As I have already said, when I come across anything I do not clearly understand (and for J. T.'s benefit I'll admit I sometimes do), I know that it worries me until I do understand all the reasons why and wherefore.

In conclusion I must thank J. M. for correcting my oversight in regards to the chord of the segment, and hope to be able to return the compliment at some future date. Trusting, Mr. Editor, that you will always temper mercy with judgment in the use of the "blue pencil" and confer a favor on

San Francisco, Cal. "GOLDEN WEST."

Remedy for B. L. K.'s Pump Trouble.

EDITOR THE PRACTICAL ENGINEER:

In regards to B. L. K.'s pump question, I would say that he has not got his valves set right or his pump would not pound. He has let his pump get rusty on one end by leaving water in it, so that he must give it too much lead, one way or the other, to make it drag over the rust. I would suggest that he take the cylinder head off and thoroughly polish the interior of the cylinder with graphite and set the valves in their normal position. If the pump must remain idle for any length of time, it should be given a thorough oiling both inside and out before shutting down.

Whitewater, Wis. J. R. W.

C. E. A.'s Valve Stem Trouble. Make Rings of Steel.

EDITOR THE PRACTICAL ENGINEER:

In the February issue, on page 30, Mr. C. E. A. tells of his troubles with the rings on his valve stem of his engine and asks for suggestions to help him. I should judge by his letter that the trouble was with the valve, it having a tendency to crowd or work toward the bonnets. I would suggest that the rings be made of steel and have them hardened, and also have hardened steel rings made to put in the face of the bonnets to act as a bearing for the rings on the valve stem. To put the rings in the bonnet, turn a recess so that they will be a tight fit and flush with the face of the bonnet; also examine the collars on the outside of the valve stem and see that they are in a position to take up their proportional share of the thrust of the valve, as by so doing the rings inside should last longer.

Fall River, Mass. M. H. H.

Can't Find the Vacuum in an Injector.

EDITOR THE PRACTICAL ENGINEER:

In the February issue there was printed an article by H. A. Cozzens. He claims there is a partial vacuum formed in an injector of the lifting type, but none in the non-lifting type after they are in operation. Now all the definitions of vacuum that I ever saw stated that a vacuum was a space void of all pressure. Now I would like to know where this supposed partial vacuum lies in an operating injector of either type. I think after the water once gets to the injector, whether lifting or non-lifting, that it completely fills every atom of space in the injector. I will admit that there is a constant effort to create a vacuum, but I have never yet been able to find a place in an operating injector for one to form.

Some engineers claim that hot water causes an injector to "break" because the vapor from the heat in the water destroys the partial vacuum. I think the injector breaks because the water is not cool enough to condense the supply of steam, and if the water does not condense the steam, there is no other way that it can acquire the velocity from the steam necessary to force it into the boiler. C. J. W.

Groton, Mass.

Remedy for Dynamo Trouble.

EDITOR THE PRACTICAL ENGINEER:

In relation to S. K.'s dynamo troubles, experience has taught me that too much lubrication on the commutator will cause overheating. Be sure the set screws are properly adjusted in all the connections. Keep the commutator round, true and clean; to do this take a thin board, put sandpaper on it the same length as the commutator and hold it against the surface of the commutator as you start up slowly. By doing this you can get your dynamo in good working order and your lights will be all right. Look out for dust and grit.

Fall River, Mass. A. J. C.

Michigan State N. A. S. E. Convention.

Although the Michigan State Convention of the N. A. S. E. will not be held until July 19th and 20th, 1907, already preparations are being made and plans perfected to make it a great success. The convention will be held in Detroit, and the local committee, headed by A. B. Benjamin, chairman; R. Anderson, treasurer, and A. W. Miller, secretary, have been active in securing a meeting hall and place for the supply men's exhibits. The Light Guard Armory and hall has been leased for this purpose and the main armory floor will be given up to the display of apparatus and supplies interesting to the engineer. Plans and other information may be obtained from A. W. Miller, 41 Greenwood Ave., Detroit, Mich.

QUESTIONS and ANSWERS

THE editor will be glad to receive from the readers of THE PRACTICAL ENGINEER, such questions relating to engineering subjects, as may, from time to time, occur to them. All questions and answers should be addressed to the editor and accompanied by the name and address of the writer, which will not be published, however, unless especially desired. It is the intention that questions shall be answered by the readers, and even though the editor may, from time to time, publish answers and questions, he especially desires the readers in such cases to contribute any further information, in connection with the points raised, that they may consider of interest. All questions and answers received by the editor will be published, as far as practicable, but he reserves the right of editing or rejecting any communication.

Oil Stains in Switchboard.

EDITOR THE PRACTICAL ENGINEER:

Will you please tell me how I can get the stain of black cylinder oil out of a white marble switchboard? When the board was stored away some of this oil was spilt on it and it looks very bad. There is considerable petroleum oil in this cylinder oil, but otherwise I do not know what is mixed in it.

Jersey City, N. J. W. C. R.

There are several methods that may be tried which would give the desired results, but the efficacy of any of these methods will depend chiefly upon the composition of the oil which stains the board.

One method would be to rub the stone with a clean cloth moistened with a mixture of equal parts of oil of turpentine and ether, and then cover the stain with some pulverized whiting and allow to remain. Then scrape off, and repeat the operation until the stain has disappeared. Another and perhaps better method is to take a solution of ¼ pound of soft soap, ¼ pound of whiting, one ounce of soda and a piece of blue stone about the size of a walnut, rub it over the marble with a piece of flannel and leave it for 24 hours. Then wash it off with clean water and polish the marble with a piece of flannel or an old piece of felt. Another method is as follows: Take two parts of common soda and one part of pumice stone, also one part of finely powdered chalk, sift it through a fine sieve, and mix it to a paste with water. Rub it well over the marble and then wash with soap and water. Still another method is to apply common clay saturated with benzine and place on the oil stain. If the grease has remained very long in the marble it is very probable that when the stain is removed the polish will be more or less injured, but it can easily be repolished when restored to its proper color.—[Ed.]

Voltage and Current Given Out by Generators.

EDITOR THE PRACTICAL ENGINEER:

In reference to generators I would like to ask the following questions:

How can a 125-volt generator deliver 10,000 amperes?

Why does a 2000-volt machine in some cases only deliver 10 amperes, and why is there such a difference between the two currents? J. M. P.

Pullman, Ill.

A 125-volt generator can develop any amount of current if the wires on the armature are made large enough so that they will not over-heat with the given load. Since the product of the voltage of the machine multiplied by its ampereage gives the capacity of the generator, it is therefore evident that for a certain output the voltage of the generator can either be low and the current high, or the voltage may be high and the current low. Whatever the two values of voltage and current are, it depends upon the design of the machine and the purpose for which it is intended.

Chemicals for Fire Extinguisher. Wire Gauges. Exhausted Dry Battery.

EDITOR THE PRACTICAL ENGINEER:

Please answer the following questions:

What chemicals are used for charging a fire extinguisher?

What size fuse wire would you use for lamp rosettes?

What difference is there between the American and the English wire gauge?

How can you tell when a dry battery is run out?

Hudson, N. Y. G. E. W.

There are a number of different compounds used for extinguishing fire which are composed of ammonium sulphate, borax, sodium phosphate, etc. A mixture which is sometimes used consists of four parts of common salt, three parts of sodium bicarbonate, and one part each of glaubers salt, water glass, and calcium chloride. Another mixture which is sometimes used consists of 30 per cent. of common salt, 40 per cent. of sodium bicarbonate, and 30 per cent. of sal-ammoniac. Another mixture consists of four parts of green vitriol, 16 parts of ammonium sulphate, and 100 parts of water.

As each 16-candle power lamp requires ½ ampere, this will indicate what size fuse to use for lamp rosettes.

The principal difference between the American wire gauge and the English wire gauge lies in the fact that for a given number of gauge, the diameter of the wire differs; for instance, the No. 1 wire with the American gauge has a diameter of .2893, and with the British gauge .3, with a No. 8 wire the diameter with American gauge is .128, and for English gauge .16, and so on.

The best way to tell if a dry battery is run out is to attach the low reading voltmeter to the terminals. If this is not available try an electric bell on a good battery, and then try it on the one under suspicion, and the difference in ring will at once indicate the difference of the battery.

Vacuum Heating System.

EDITOR THE PRACTICAL ENGINEER:

Will you kindly publish in your paper a description of the vacuum heating system? W. T. B.

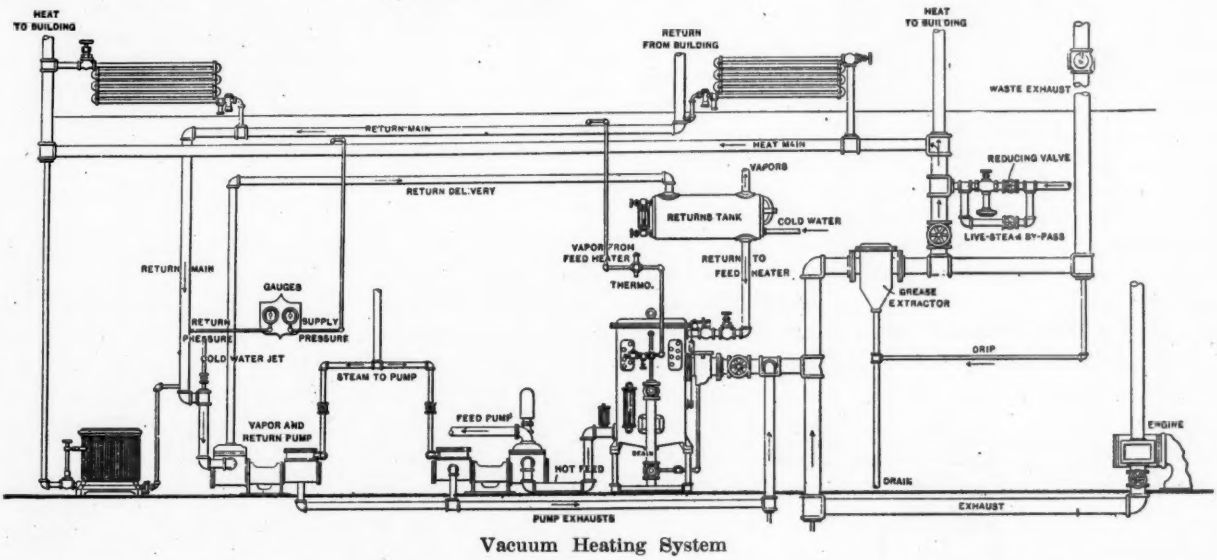
Anna, Ill.

In a vacuum heating system the pressure in the radiators is less than that of the atmosphere, the circulation of steam through the pipes being produced by suction rather than by pressure. There are different vacuum heating systems in use, one of which is shown in the accompanying illustration. This system, known as the Webster system, is strictly a two-pipe system. The return line is connected to the vacuum pump and by the constant vacuum maintained, the air and condensation are separated from the steam supply without the loss of steam.

In the Webster system, as shown, the exhaust steam is piped from the engine, one branch of which goes to the feed-water heater, while the other is carried upward and through the grease extractor, after which it branches into two lines, one

connected to the heating mains and the other connected to the exhaust pipe on which there is a back pressure valve. Live steam can also be introduced into the heating main by means of a reducing valve and by-pass, as shown.

After the steam is distributed to the radiators and coils in the usual manner it passes through them at a speed largely dependent upon the automatic thermostatic valves placed where it is usual to find the outlet valve of the radiator. The main return is brought down to a vacuum pump which discharges into a return tank, where the air passes off through a vapor pipe at the top. The condensation flows into the feed-water heater, from which it is automatically pumped back into the boiler, the exhaust from the pump going into the heating system. A small cold-water jet is connected into the suction of the vacuum pump for the purpose of increasing the vacuum in the heating system by a partial condensation of the steam at this point.



Vacuum Heating System

The outlet valve on the radiators can be regulated to give any temperature in the radiator desired. They are thermostatic valves, and by preventing the discharge of the steam through them, the possible short circuiting of the system is avoided.

The advantages which a vacuum system possesses over a back pressure system are as follows: It does away with the back pressure on the engine; it removes the air from the coils and radiators so that all portions of the system are available for heating; water hammer is avoided because of the complete drainage of the horizontals; small return pipe can be used if desirable.

Rattling Corliss Valves.

EDITOR THE PRACTICAL ENGINEER:

The head-end steam valve in our Corliss engine rattles when the load is light and steam pressure is high; when the load is heavy or the pressure is reduced, the noise ceases. What is the remedy? G. C. B.

Paris, Mo.

The rattling of the head-end steam valve of your Corliss engine, when the load is light and the steam pressure is high, is undoubtedly due to the fact that the cut-off occurs very early in the stroke, causing the expansion line of the indicator card to be carried below the atmospheric line. This causes a partial vacuum in the cylinder and consequently causes the steam valve to rattle. The probable reason why only one of your valves rattle is because the cut-off takes place in one end of the cylinder sooner than in the other. When steam pressure is reduced, this noise ceases, because the lower the initial steam pressure the longer the cut-off and consequently the less expansion, which does away with the rattle. The same thing is true when the load increases. It is for this reason among others that many engineers always reduce the working pressure of the boiler when the engine is running lightly loaded, increasing the working pressure when the load goes on. When running lightly loaded, with a good engine, 80 pounds steam pressure has been found to work very satisfactory, and with heavy loads a steam pressure of 120 pounds is more desirable.—[ED.]

He Who Steals This Man's Brains Steals Trash.

EDITOR THE PRACTICAL ENGINEER:

We have a man here who runs a traction engine and who makes the following assertions:

1. A new steam gauge bought from a supply house is not correct; to make it so it must be sent to the factory to have it tested before it is put on the engine.

2. He asserts that he can tell how high the pressure is without a gauge by the sound of the exhaust.

3. He can do actual work (threshing grain) with 20 pounds of steam, engine 8"x10", 250 revolutions per minute. The engine carried 130 pounds of steam at popping-off point; his gauge got light on him and he screwed the pop-valve down, and when a new gauge was applied it registered 180 pounds at popping-off point; that is why he says a new gauge is not correct.

What is your opinion of this man?

Carleton, Neb. T. C. B.

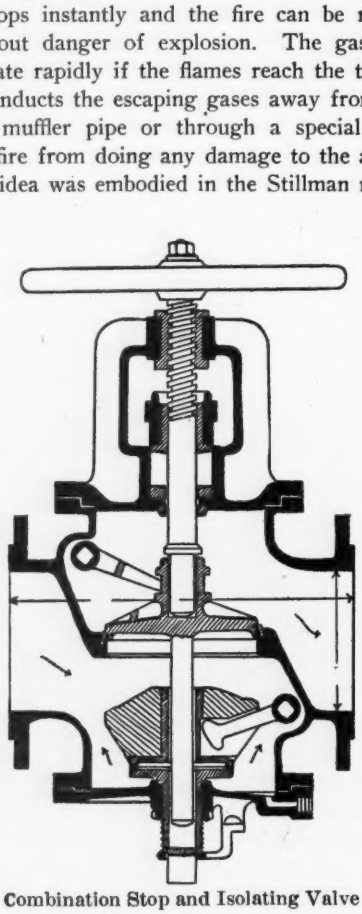
Since the records show that a large majority of the total number of boiler explosions occur on threshing engines, we think that this mute evidence will indicate the amount and quality of brains usually to be found around such types of machines.—[ED.]

Exhibit of Mechanical Safety Devices.

Devices of all kinds for protecting the life and limb of the industrial worker were exhibited in the American Museum of Natural History, New York City, from January 29th to February 12th. The exhibit was held under the auspices of the American Institute of Social Service and it included working models, photographs, machines in operation and charts and diagrams of nearly everything that is being done in the United States and abroad to prevent accidents.

Mechanical appliances predominated the exhibit, and most of them were comparatively new to the general public. One of the interesting things shown was the new and simple safety vent for volatile liquids, one of the main life-saving things of will not go through fine wire gauze. A fusible plug soldered with soft metal is blown out when the flame comes in contact with the can or tank containing the naphtha or gasoline, and while there is a blaze on the outside, no explosion can result, the present time. The vent is based on the principle that flame as the body of the liquid is protected. This arrangement can be applied to any container, and in case of an automobile, the machinery stops instantly and the fire can be readily extinguished without danger of explosion. The gases being released, generate rapidly if the flames reach the tank. A pipe connection conducts the escaping gases away from the vehicle through the muffler pipe or through a special pipe, which prevents the fire from doing any damage to the automobile.

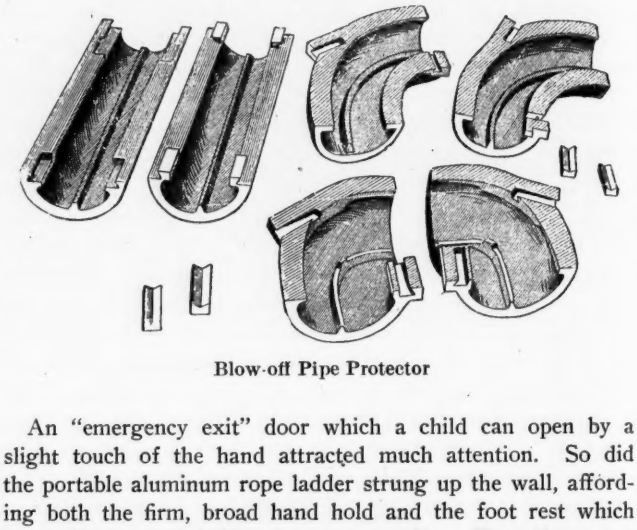
This same idea was embodied in the Stillman non-explosive



Combination Stop and Isolating Valve

safety lamp. The wick is dressed in gauze and fed from the bottom of the lamp, keeping the oil cool and away from the point of ignition, and insuring excellent combustion. The oil is held in solution in wool with which two-thirds of the lamp is stuffed, and feeds slowly and economically. The lamp or lantern can be overturned and will not explode, as the flame cannot reach the oil.

To minimize the dangers of fire is the humane idea embodied in many of the devices. A pair of lace curtains hanging over a booth were the illustrations of a "fireproof" starch, the use of which bids fair to do away with a large percentage of the accidents resulting from the hanging of light curtains near gas jets. The attendant took a bit of material stiffened with chemically-prepared starch, and held it in a flame, the result being merely to char and blacken, no blaze being seen.



Blow-off Pipe Protector

An "emergency exit" door which a child can open by a slight touch of the hand attracted much attention. So did the portable aluminum rope ladder strung up the wall, affording both the firm, broad hand hold and the foot rest which the ordinary rope ladder does not provide. Then there was the rope fire-escape which the traveler may carry in his trunk if he will, and which appears to be, as claimed, "self-operative," leaving but little to be desired. The loop once passed around the body under the arms and the hooks attached to the window ledge, all the operator has to do is to drop himself, thus supported, out of the window to safety from the roaring flames which pursue him.

There were models shown, of better arrangements of water supply, by which for high buildings unfailing pressure is afforded from compressed air tanks set in the ground. The same system provides also for security in elevators, the compressed air system making falling a practical impossibility.

New devices for railroads' use were not so numerous; for human ingenuity seems to have been largely expended in providing security. A new boltless rail-joint, so constructed that it cannot bend or spring up, was shown, and that, it is claimed, can be adapted to all climates. It consists of several parts fitting into each other, notched and set to allow for the expansion and contraction of the rail. The shoulder plate eliminates waving and creeping of the rail; and patent angle spikes are used, which hold the ties fast to the bottom of the plate.

A safety steel car brake, whose scheme of safety is the provision of an extra chain, kept new and unworn and ready instantly to take the place of the working chain, should it give way under unexpected or sudden pressure, is one of the things that is approved by the crowds at the exposition. So are the fenders which are kept out of the way under the car when not needed, and can be quickly dropped by the motorman with a touch of his knee.

The majority of the safety devices shown were for use in the shops. There were several plans for engine stops and speed limit devices, by means of which the engine automatically closes down when the danger point is reached. Safety collars were shown for emery wheels used for grinding; these ar-

rangements do not prevent the wheel from breaking, but hold the parts firmly together in case of fracture. Machines were shown with all the gearing on the inside of the machine, and rubber mats to prevent workmen from slipping were included in another exhibit.

A new and inexpensive device for protecting the blow-off pipes of steam boilers was particularly interesting to engineers. It consists of a sleeve or covering of cast iron divided lengthwise, and has ribs projecting inwardly that make an air space of about half an inch between the pipe and sleeve. When the sleeve is run through the rear wall, or even part of the way, if a small space is left open around the blow-off pipe the draft inward will cause air to pass in and through this space to the elbow, and prevent the pipe from getting much hotter than the temperature of the water it contains. The pipe will also be protected from deterioration and destruction by the character of the escaping products of combustion, and from expansion and contraction, caused by the changes of temperature of the escaping gases which envelop it when not properly protected. The sleeve can be removed and replaced at pleasure for inspection of the pipe. It is fastened by a locking device inside, which is unlocked when either half of the sleeve is moved about an inch laterally. The elbow sleeve is constructed on the same principle, with ribs and an air space, and is fastened with keys in recesses. It can also be removed and replaced for inspection of joints at elbow.

An exhibit of combination stop and isolating valves was also shown. These valves are capable of being closed automatically in both directions in case of accident—that is, either in the event of a fracture or mishap to the steam-pipes or engines on the one hand, or in case of any accident or failure in any part of the boiler. They also automatically connect the boiler in which steam is being raised with the boilers at work and under steam. A safety slide valve was also shown which prevents accidents to an engine due to a dose of water.

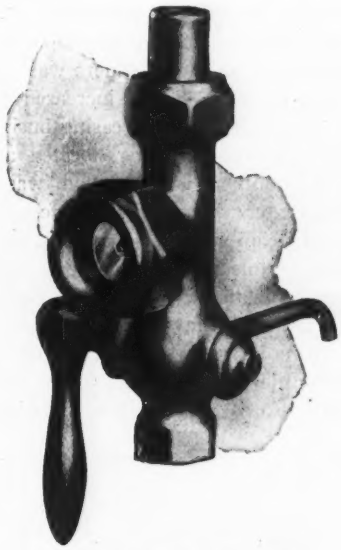
Among the other exhibits were arrangements for launching life-boats in a heavy sea; automatic gas burners, which turn the gas off when the flame is blown out; goggles and devices for protecting the eyes, ears and noses of operators working among dust, vapors and fumes, and various statistics showing the number of accidents in the United States and the liability caused thereby.

The Multiplus Sight Feed.

The Multiplus sight feed, which has just been put on the market, and is furnished free with all new Improved Rochester Automatic Lubricators, is, as may be seen by the accompanying illustration, a combination sight feed and three-way cock. This combination has all the advantages of the sight feed, which enables the engineer to see at a glance whether or not oil is being pumped to the cylinder or point of delivery, and it also has the certainty of the three-way cock, by means of which the exact amount of oil being fed can be determined by simply turning the handle.

The sight feed is simple in construction, being composed of a chamber, one side of which is a heavy glass disc, against which presses a hollow plunger. In order to pass from the lubricator to the point of delivery the oil must be forced through this plunger, which has an opening in the end. The oil in forcing its way between the glass and the end of the plunger, moves the plunger back so that only the oil is seen behind the glass, but as soon as the pressure is relieved it resumes its normal position, and the light color of the brass is seen instead of the dark oil.

It will thus be seen that when the oil is being fed, that the sight feed will keep up a continual "winking." There is always



The Multiplus Sight Feed

a solid column of oil under pressure in the Multiplus sight feed, and because of this it is said to have the advantage over glycerine and water sight feeds.

Green, Tweed & Co., 109 Duane Street, New York, are the manufacturers, from whom other information can be obtained.

The Progress of the D. T. Williams Valve Company.

Mr. David T. Williams, connected with The Lunkenheimer Company for fifteen years as vice-president and general manager, resigned that position in October, 1904, and shortly after,

Mr. D. T. Williams

in November of the same year, founded and organized The D. T. Williams Valve Co., which bears his name, with a capital stock of $100,000.

Immediately after they secured their present quarters at 904-

06-08-10 Broadway, and which was put in operation in April, 1905, their products were given wide publicity through the different technical and trade journals, which resulted in the receipt of an unusually large amount of business. Within sixty days the capacity of this plant was overtaxed, which made necessary its operation both day and night.

Business assumed such phenomenal proportions that on June 15, 1906, a meeting of the stockholders was held, wherein the capital stock of the company was increased to $200,000. In order to cope with the rapidly increasing business, in October, 1906, a large seven-story building, located at 521-523 Hunt Street, which was only recently erected, was purchased, and plans were immediately drawn up to convert this building into the most modern steam specialty factory in the country.

The purchase of this building was one of the largest real estate deals known in that city for some time, inasmuch as it is looked upon as a very favorable manufacturing site, being located right in the heart of the city, having a frontage of 50 feet, running to a depth of 267 feet to the Pennsylvania Railroad, which will afford them excellent shipping facilities.

The New Home of the D. T. Williams Valve Co.

One of the principal features of the new plant will, of course, be a most modern power equipment, a first-class brass foundry for casting the company's line of specialties, and the most modern of machine tools and appliances for finishing their products. The larger machines will be direct motor drive and the smaller machines driven in groups by a large motor.

The rapid success which this company has attained in the couple of years that it has been in business seems improbable, inasmuch as the present plant which they now occupy has only about 18,000 square feet of manufacturing space, while the new plant which they have purchased has over 94,000 square feet, which increases their capacity five times.

They make a complete line of brass and iron stop valves, check valves, gate valves, water gauges, oil and grease cups, lubricators, steam traps, separators, generator valves and other steam engineering appliances. The success of this company is due to the fact that they manufacture nothing but the highest grade of steam specialties, and in proof of this statement they point to the fact that a large portion of their business is for the United States Navy, where quality is the most important consideration.

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Snow-Clad Heights to Furnish City's Water Supply.

The Board of Consulting Engineers engaged by the city of Los Angeles, Cal., to report upon the feasibility of obtaining a water supply for that city and the surrounding country for irrigating purposes, on the fruit and truck farms, has just submitted its report, which in brief is that the project is admirable in conception and outline, in every respect feasible, involves no difficulties of engineering or construction other than those arising from mere length and distance, and it is full of promise for the continued prosperity of the city of Los Angeles.

The *Engineering News* in editorially commenting upon this report declares it to be the boldest municipal water supply scheme ever projected. The plan contemplates gathering water above the snow lines in the Sierra, going as high as 3800 feet, and a distance of 226 miles from Los Angeles, conducting the water supply by open masonry conduits, underground masonry tunnels, steel flumes and syphons, the conserving of the supply in storage reservoirs, one of which alone has a capacity of 85,000,000,000 gallons, the utilization of the water supply for the development of power, all of which can be done at an expenditure of approximately $25,000,000. If carried out the system will provide a water supply of 410 cubic feet per second throughout the year, owing to the enormous storage to be provided to carry over the dry season of the year. The auxiliary power development will amount to approximately 50,000 horse power, available every day in the year for transmission to Los Angeles.

The possibility of a small town like Los Angeles, with a population of only 100,000, contemplating such a gigantic water scheme is due to the necessity for an ample supply of water for irrigating in the vicinity, extensive cultivation of truck gardens and orchards in that locality being carried on to a degree not surpassed anywhere in this country.

It is estimated that it would take five years at least to complete the plant, the controlling factor probably being the 25,000-foot tunnel which must be driven from headings, two of which will start about 350 feet shafts in the Antelope Valley. It is contemplated that a cement mill would have to be built on the site to furnish cement for the concrete work, and a railway would have to be built to carry supplies.

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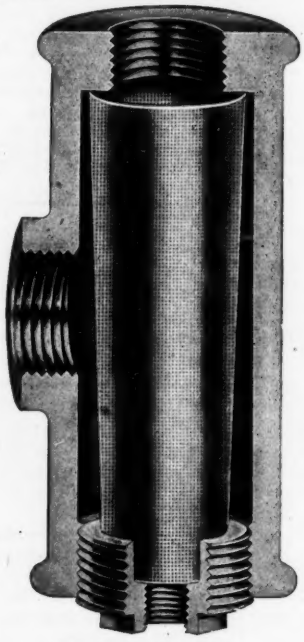
The Wright Filter.

The accompanying illustration represents a new device recently placed upon the market by the Wright Manufacturing Company, of Detroit, Mich., for use in connection with water pipes, boiler feed and meter systems. It will prevent sand, scale, vegetable and floating substances from reaching the boiler, and it will not allow these substances to interfere with the free and perfect operation of water meters.

The Wright Filter, as it is called, is designed and con-

structed in the most approved and substantial manner. It is made of brass, many times larger than the inlet. A blow-off valve screwed into the opening in plug and opened occasionally, will serve to keep the filter free from accumulated foreign matter. The filter tube can easily be removed by unscrewing the plug to which the tube is attached.



The Wright Filter

Before being placed on the market, this filter has been applied under various conditions for several years, so that it could be thoroughly investigated under practical service, and it is said to have answered all requirements in a thorough manner. It is made in sizes of from one to three inches.

Book Reviews.

Self-Propelled Vehicles, by James E. Homans. Size, 5½ x 8½. 600 pages and 399 illustrations. Published by Theo. Andel & Co., New York City.

Since the advent of the automobile there have been many changes in the design and construction of the self-propelled vehicle, with the result that to-day there are many forms of complex machines, which are very difficult to understand without a wide mechanical knowledge. Mr. Homans seems to have had an almost unlimited task before him in writing a book on this subject, but he has admirably succeeded in giving to the average person a most comprehensive idea of the management and construction of modern automobiles which is up to the minute.

Starting in with a brief history of the self-propelled vehicle, the book takes up subjects of compensation and compensating devices, methods of the transmission of power, the steering of a motor vehicle, wheels and tires, types and merits of the automobile, theory of the heat engine, parts of a gas engine, two-cycle and four-cycle gas engine, conditions of compression and expansion, water and air-cooling for the cylinder, carburetters and carburetting, ignition, care and operation of gasoline vehicles, electric vehicles and their operation, construction and operation of storage batteries, steam carriages, the steam engine and different forms of steam boilers, boiler feeders and water level regulators, etc.

In the treatment of the above subjects, theoretical matters are introduced only where the explanations require them, and each subject is treated in a clear and comprehensive manner. The book is exceedingly well printed and the illustrations are excellent and should be of much value to vehicle owner, operator or repairer.

Gas, Gasoline and Oil Engines, by Gardner D. Hiscox. Size, 6x 9½. 425 pages and 351 illustrations. Published by Norman W. Henley Publishing Co., New York City. Price, $2.50.

The far-reaching influence of the explosive type of motor has made itself felt in almost every industry, so that it is of much importance that this type of prime-mover should be thoroughly understood. Mr. Hiscox was one of the earliest writers on this subject, and the present book, which is in its fifteenth edition, contains not only the fundamental facts pertaining to the gas, gasoline and oil engine, but also all the newer points of construction which have more recently taken place.

The book describes the theory of the gas and gasoline, the utilization of heat and its efficiency in explosive motors, combustion, wall-cooling, compressor efficiencies, materials of power used in explosive engines, carburetters and vaporizers, governors and valve-gears, cylinder lubrication, constructive details of explosive motor, various types of motors, measurements of power, management, testing, marine, bicycle, tricycle and automobile motors, oil motors. A very interesting chapter is devoted to producer gas and its production, in which the various types of apparatus in use are described.

This book is well written and exceedingly well illustrated, and the price is very moderate for the character of book and the information which its contains.

Modern Plumbing, Illustrated, by R. M. Starbuck. Size 7½ x 10½. 390 pages, 55 full-page plate illustrations and numerous tables. Published by Norman W. Henley Publishing Co., New York City. Price, $4.00.

This book is a thorough and practical work showing the modern and most approved methods of plumbing construction, and illustrating and describing the drainage and ventilation of dwellings, apartments, public buildings, etc. It is designed to cover the entire field of plumbing as far as possible, and takes up not only plumbing as practiced in towns and cities under strict plumbing regulations, but plumbing construction under conditions usually found in country districts, where the problems which arise are often of an entirely different nature, and where there is not in existence any public regulation of sanitary work.

To most engineers, who must be more or less acquainted with plumbing around the power plant or in the building which comes under his supervision, this book should be of decided value.

Jamaica Earthquake Survivor Sends Greetings.

EDITOR THE PRACTICAL ENGINEER:

I am very happy to inform you that I am alive. I have sent you under another cover a copy of our daily newspaper, from which you will note the terrible damage done to the city of Kingston by the earthquake on Monday, January 14th.

I hope you will continue to send THE PRACTICAL ENGINEER.

Kingston, Jamaica. A. C. DAVIDSON.

TRADE NOTES

EDITED BY THE ADVERTISING MANAGER

J. H. Pearson & Co., 130 Centre St., New York City, are giving a fine pocket knife free with the first order for five yards of Vellumoid Sheet Packing. This packing is totally unlike any other sheet packing and is said to give excellent results, especially on pumps handling oils, gases or iquids of any kind, and also for gas engine work. A sample of the packing will be sent free to any one interested.

Mr. C. H. Mosher has been engaged as Eastern representative of the American Steam Gauge and Valve Mfg. Co., of Boston, to succeed Mr. R. M. Turner who has been appointed manager of the company's Publicity Department.

"The Penberth Engineer and Fireman" is an interesting and instructive little journal published monthly by the Penberth Injector Co., 344 Holden Ave., Detroit, Mich. It will be mailed free for three months to any reader of THE PRACTICAL ENGINEER upon request.

The business hitherto carried on by Mr. John A. Caldwell at 45 Broadway, New York, in fuel-saving devices, including the widely known "Ados" No. 2 Recorder, has been merged into the Sacro Fuel Saving & Engineering Company.

This Company has just been incorporated under the laws of the State of New York, with a capital of $100,000, to take over the American interests of Sanders, Rehders & Co., Ltd., the well known fuel economy specialists of London and Manchester, and to manaufacture on this side their various apparatus.

Commodious offices in the new West Street Building, New York City, have been engaged, and workshops and temporary offices at 81-85 Washington Street, New York.

Mr. Sanders, the chairman of the abovenamed firm is the President and Mr. Caldwell, the General Manager of the Corporation.

Sales of White Star Oil Filters by the Pittsburg Gage & Supply Co., Pittsburg, have recently been made to the following concerns: Eleanora Mines, R. & P. C. & I. Co., Eleanora, Pa.; Donohue Coke Co., Greensburg, Pa.; Wm. H. McCarthy, Pittsburg, Pa.; Pittsburg Steel Construction Co., Economy, Pa.; Penna. R. R., Pittsburg Shops, Pittsburg, Pa.; Trumbull Electric Mfg. Co., Plainville, Conn.; Powell, Clouds & Co., Philadelphia, Pa.; Pratt & Whitney Co., Hartford, Conn.; Pittsburg Steel Co., Monessen, Pa.; John A. Roebling Sons Co., Kinkara, N. J.; Bryan Marsh Electric Co., Central Falls, R. I.; Louisville Lighting Co., Louisville, Ky.; Auburn & Alton Coal Co., Auburn, Ill.; Laurel Mfg. Co., Laurel, W. Va.; American Steel & Wire Co., Chicago. Ill.; Carterville & Big Muddy Coal Co., Carterville, Ill.; Russel Coal Mining C., Clymer Pa.; Milburn Wagon Co., Toledo, O.; Pittsfield Eectric St. Ry. Co., Pittsfield, Mass.; Cincinnati Water Works, Cincinnati, O.

The Patterson Mfg. Co., 4 South Front St., Baltimore, Md., are offering Patterson Hydraulic Damper Regulators as low as fifty dollars, which seems like a very low price and we understand that they are receiving a large volume of orders.

Mr. Charles K. Thomas, formerly general sales agent of the Lunkenheimer Co., has severed his connection with that company and in future will represent the D. T. Williams Valve Co. as its Eastern sales agent. Mr. Thomas is secretary of the National Exhibitor's Association, and is well known and popular. His address has been changed to 904 Broadway, Cincinnati.

Engineers who are troubled from insufficient draft will do well to write the New England Roller Grate Co., for a circular describing the Bausch Draft Inspirator. Address, 310 Main St., Springfield, Mass.

The Male and Female Kewanee Union is described in an attractive circular issued by Western Tube Co., Kewanee, Ill. The special advantage claimed for this union is that no nipple is required, the connection being made direct with the male end.

The Economy Faucet Co., 97 Weybossett St., Providence, R. I., are offering to send one of their Economy Faucets for free trial, to be returned to them if not satisfactory. This faucet is designed to furnish hot water from the could water pipes without the expense of installing hot water pipes. This is accomplished by attaching the faucet to the cold pipe and connecting a small steam pipe, thus making it possible to procure either hot or cold water from the same faucet with but small expense.

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Thompson's Dynamo Electric Machinery

LATEST EDITION

In 2 large volumes, containing 1864 pages, 1119 illustrations, 19 pages of colored wirings and 56 large folding drawings.

This is the most complete and authoritative work on Direct Current and Alternating Current Dynamos and Motors.

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Mr. Frank H. Waite, Philadelphia representative for McLeod & Henry Co., is a frequent visitor to the offices of THE PRACTICAL ENGINEER. Mr. Waite has had wonderful success with "Steel Mixture" and his jolly disposition, determined effort and his little sample case of a boiler setting have won for him the success which he has attained.

FOR SALE— A fully equipped machine shop, building steam engines and ice machines. Modern buildings, large grounds, and railroad siding. Plenty of orders ahead. Location eastern Pennsylvania. A good opportunity for a mechanical engineer. Box 8, The Practical Engineer, 46 N. 12th Street, Phila.

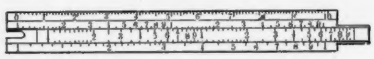
WANTED—Engineers, Firemen, Electricians and all steam users. Do you want to be "put wise"? Send for 52 page pamphlet containing Questions asked by the different Examining Boards throughout the country. Sent FREE. GEO. A. ZELLER BOOK CO., 62 So. 4th St., St. Louis, Mo.

FOR SALE—Cyclopedia of Modern Shop Practice. A complete reference work for Machinists, Foundrymen, etc. Leather binding. Four volumes. Cost $18.00. Will sell for six dollars. Address P. E. L., Box 425, Chicago, Ill.

ENGINEERS. Send your address, and *who employed* by, and we will send you a *Set of Corliss Valve Rod*, or *Throttle Valve Stem Packing free of charge. Express prepaid.* Give *diameter of rod, Gland, and depth of box.* Ideal Metallic Packing has no *equal.* We have the documents to prove it. Ideal Metallic Packing Co., Box 52, St. Paul, Minn.

The man behind the

RUNNERLESS SLIDE RULE



is satisfied.

"Your formulas are the best I have ever seen." J. J. C.

"I like your Slide Rule very much. First I missed the runner to keep the place, but now I think a runner will interfere with reading the rule." I. S. D.

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Wanted Salesmen traveling among engineers to sell the France Metallic and Fibrous Packings. Good inducements on unoccupied territory, Address
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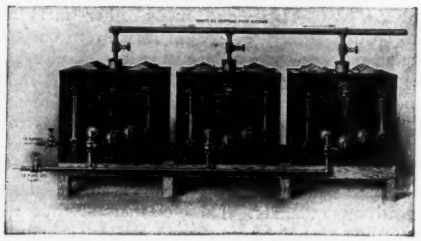

You won't make a mistake in getting the "Unit" Oil Filter

It's the filter occupying a small space—is but 42 inches long, 36 inches high, 28 in. wide, and gives a filtering capacity of from 200 to 250 gallons every 24 hours. Can be cleaned without stopping filtration and may be used with or without an oiling system, so as the plant increases, additional units may be installed.

If you are interested in power plants or a manufacturing concern, you should have a copy of our new 64-page catalog just issued. It's the most handsome ever put out by any oil filter concern, and fully describes the "Cross, American, Warden and Unit" Oil Filters, the "Burt" and "Standard" Exhaust Heads and the "Burt" Ventilator.

The Burt Mfg. Co.

Largest Manufacturers of Oil Filters in the World

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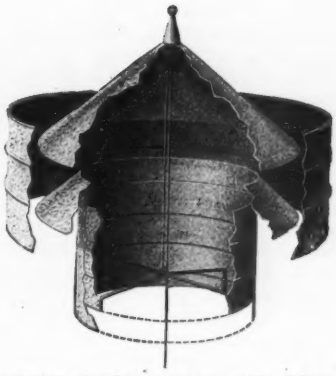


Sectional view showing metal top with sliding-sleeve damper (patented).

The Air in the Engine Room

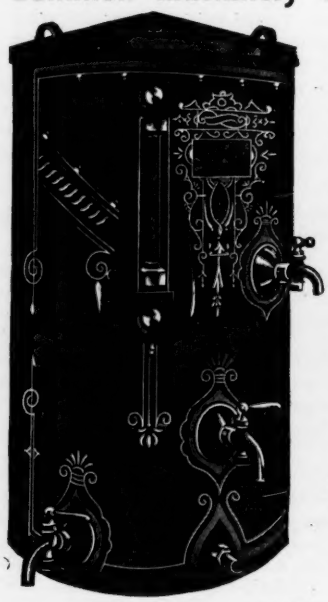
Will be always clean and pure after the Burt Ventilator is installed. Having our sliding-sleeve damper which absolutely prevents any back current of air, it is never clogged with snow, ice, etc., but is always free and open. Is noiseless, stationary and cannot get out of order. When glass top feature is used it is a combined skylight and ventilator in one; it can be entirely closed without obstructing in any degree the passage of daylight.

The Burt Mfg. Co.

Largest Manufacturers of Oil Filters in the World

204 Main Street, AKRON, OHIO, U. S. A.

For Filtering Engine and Common Machinery Oils,



use a Cross Oil Filter. It removes dirt and grit from the oil by straining it through waste, then washing it in pure warm water. This gives you the oil to use over and over again.

Requires little or no attention after starting, while the first cost is the only one, beyond a few cents per year for waste.

It cannot clog and has nothing to break or get out of order.

The Burt Mfg. Co.

Largest Manufacturers of Oil Filters in the World

204 Main Street AKRON, OHIO, U.S.A.

Prevent Drenching and Rotting of the Roof.

The Burt Exhaust Head attached to the exhaust pipe prevents all wet steam and oil from escaping. It saves water because the same water may be used over and over again after cylinder oil is removed, and because the mineral elements are removed from the water, and keeps the boilers clean and saves fuel. Has but one steam chamber—the entire head. No baffle plates, diaphragm or scrap metal.

The Burt Mfg. Co.

Largest Manufacturers of Oil Filters in the World

204 Main Street, AKRON, OHIO, U. S. A.

James L. Robertson & Sons, 40 Warren St., New York. the well-known makers of Robertson-Thompson Indicators and Eureka Packing, have sent THE PRACTICAL ENGINEER an order for twenty-four pages of advertising—two pages each issue for a year. In all of this space only two subjects will be prominently discussed, Eureka Packings and the Robertson-Thompson Indicator with its accessories, Victor Reducing Wheel and Willis Planimeter. Two pages every issue costs a good deal of money. Not many advertisers would have the courage to do it, for it takes courage to plunge on space, but with Messrs Robertson & Sons it is not a wild plunge to satisfy a sudden whim or fancy, but merely a continuation of a well defined policy. For many years they have been regular and consistent advertisers in the engineering field. Each year they have added to their advertising appropriation. When they began in THE PRACTICAL ENGINEER it was an eighth page, then a quarter, then a half, then a full page, and now two pages, so that in doubling their space for 1907 they are only doing on a large scale that which they have done many times before. It is not a gamble, not even a speculation, but the steady pursuit of a settled and successful business policy, proven by years of practical experience with the same two high-grade specialties—Eureka Packing and the Robertson-Thompson Indicator, both of which were unknown until Mr. Robertson took them up, perfected them, and began his never-let-go campaign of persuasive publicity through the engineering papers, which has proven so profitable and which has made him such a host of friends, causing his products to be used all over the world, making the name of Eureka Packings familiar to every engineer in North America.

The Pittsburg Feed Water Heater Co., Pittsburg, Pa., report the following recent sales of their heaters:—Bessemer & Lake Erie Railroad Co., Greenville, Pa., 1-1500 H. P.; H. C. Frick Coke Co., Frauger Station, Pa., 1-1000 H. P.; Hygenic Ice & Cold Storge Co., Pulaski, Va., 1-100 H. P.; Campbell & Deane Co., Stray Plains, Tenn., 1-100 H. P.; Sibley Lumber Co., Detroit, Mich., 1-175 H. P.; Perkins Sanitary Refrigerator Co., Battle Creek, Mich., 1-150 H. P.; Leechburg Electric Light & Power Co., Leechburg, Pa., 1-300 H. P.; American Car & Foundry Co., Detroit, Mich., 2-1500 H. P.; Merkle Machinery Co., Kansas City, Mo., 1-150 H. P., making a total horsepower of 6475.

The H. W. John-Manville Co. have opened a new branch at 214 Main St., Buffalo, in charge of Mr. Geo. A. Schmidt.

In the show window of a hardware store down in Bakersfield there is displayed a number of articles of clothing and tools used by miner L. B. Hicks, who was entombed for fifteen days in the narrowest and darkest of subterranean cells in the heart of the mountains near Bakersfield.

Among the tools that are shown in the window is one that played a very important part in saving the man's life, so that he might live until his companions could reach him. This tool is Starrett's Hack Saw Blade. When this man was buried seventy feet below the surface, and he was pinioned under a heavy car by iron rods, he used the hack saw to cut himself free, thus saving his life until more heroic measures could be taken.—*The Hardware Journal.*

The G. H. Wheeler Manufacturing Co., of Philadelphia, has just issued a circular on the G. H. Wheeler Underwriter Fire Pump, which describes in deail the difference between the "National Standard" and the "Trade Pump."

The same circular describes the C. H. Wheeler Auxiliary Underwriter Fire Pump. This is practically a new pump designed by his firm—it is approved by and built according to underwriter specifications, and recommended by them for the purpose of automatically keeping a pressure on the fire mains and at the same time supply a small supply of water until the large pump can be started.

The Wheeler Co. report their pump department as being especially busy at the present time.

The Eddy Valve Co., of Waterford, N. Y., have issued a new 286 page catalogue describing their complete line of taper-seat and parallel-seat valves, check valves, foot valves, sluice gates, indicator posts and fire hydrants. This catalogue is issued to supersede their catalogue of 1901. It contains some 200 hundred illustrations showing their complete line in detail, and with the tables of sizes, prices, styles and full information intended for the guidance of the intending purchaser. Engineers in charge of construction work, and others having use for this class of valves will do well to write for a cpyy.

A partial list of the users of Wolff Belt Dressing, as shown in a recently issued pamphlets, includes some of the great railway systems and many large industrial concerns. The advantages of the use of this belt dressing, as set forth, are many. They claim great additional life to any belting, leather or rubber, keeping it clean and pliabe and at a reduction of 50 per cent. in the expense.

The pamphlet referred to and details of their special trial offer, which is made for the purpose of demonstrating in individual cases the truth of their statements and claims, may be had by addressing the Norbert-Wolff Company, 472 Greenwich St., New York City.

The Bates Machine Co., of Joliet, Ill., have opened a sales office at 1616 Fisher Building, Chicago, with Mr. Thos M. Yoder in charge.

Mr. John E. Zimmerman, formerly secretary of the American Pulley Co., has become a member of the firm of Dodge & Day, Engineers, Drexel Building, Philadelphia.

The Cramer-Krasset Co., 157 Huron St., Milwaukee, Wis., have issued a new catalogue describing Bangs' Automatic Oil Cups, a copy of which will be mailed to any reader upon request.

An attractive new pamphlet entitled, "The Minute Man" has been received from Revere Rubber Co., 77 Bedford St., Boston, Mass. It is devoted to Revere Spiral Packing. Copies will be mailed upon request.

Few people realize that one-eighth inch of scale in the tubes of a 200-H. P. water tube boiler will fill two big wagons when taken out, and that this scale if left in the boiler decreases its steaming capacity about 30 per cent.

These and many other facts about boiler scale are brought forcibly to one's attention in the new 48-page treatise "Boiler Scale and Its Removal" just issued by the Lagonda Mfg. Co., of Springfield, Ohio. Forty illustrations show how the tubes of any kind of water tube boiler, economizer, evaporator or condenser can be cleaned with the Weinland Mechanical Cleaner or the Weinland Direct Motor Cleaner. These cleaners are operated by steam engines, gas engines, electric motors, shafting, or water motors. This book is being sent free to all who write for it.

The Direct Separator Company have recently arranged with the Dashiell Engineering Co., No. 328 Candler Building, Atlanta, Ga., to handle their specialties in the South, and with J. J. Dwyer, No. 317 American National Bank Building, St. Paul, Minn., to sell these goods in the West, and with A. C. Stansill, No. 404 Terry Building, for the State of Virgania.

The tenth edition of "Graphite as a Lubricant" has just been printed and is now being distributed by the Joseph Dixon Crucible Company. The subject of lubrication in general, and graphite lubrication in particular, is exhaustively treated. All the good features of the previous edition are retained, but the very latest information—both scientific and practical—that has to do with the subject is added, making it valuable to the student of theory and the man of practice.

The publication is arranged and indexed so as to readily enable the reader to find the information he is most interested in. Those who desire to post themselves on graphite lubrication should secure a copy of "Graphite as a Lubricant" by writing the Joseph Dixon Crucible Co., Jersey City, N. J.

The Truxal-Painter Manufacturing Co., Chattanooga, Tennessee, are issuing a catalogue describing the Painter Hoist. It is driven by an electric motor or gas engine and can be easily moved from job to job and is cheap to operate. This catalogue will be sent to any one interested.

The Blackmer Rotary Pump, which, it is claimed, will handle a larger volume of fluid with less power than any piston pump, is comprehensively described in a finely printed catalogue which we have received from Blackmer Pump, Power and Mfg. Co., of Petoskey, Mich. There are several cuts showing sectional and exterior views of the pumps and also a table of sizes, capacities and prices, together with a table giving loss by friction of water in pipes.

The Du Bois Iron Works, of Du Bois, Pa., have taken over the entire business of the Lozier Engine Mfg. Co., manufacturers of gas engines. The Du Bois Iron Works is a million dollar corporation and will push the sale of their engines vigorously. A number of improvements have been made which makes it possible to operate Du Bois engines (the name they will be sold under) on natural, illuminating, coke over gas, gasoline, alcohol, distillate, crude oil and kerosene in sizes ranging from 5 H. P. to 300 H. P.